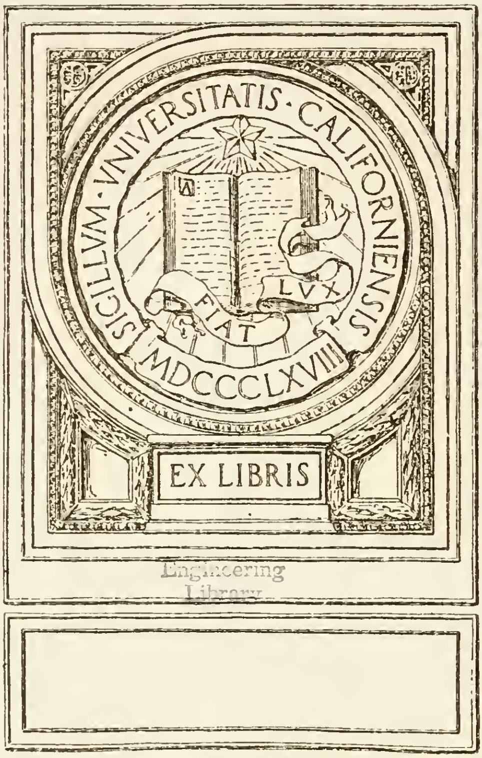
Military Sketching *and* Map Reading

—Grieves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MILITARY SKETCHING

AND

MAP READING

Including Panoramic Sketching and Aerial Photography

By

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Fourth Edition
Revised and Enlarged

Washington
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1921

Contents

PART III.—PANORAMIC SKETCHING

PART IV.—TRAINING CAMPS

Preface

The first edition of this book was written in 1914, and consisted of a series of lessons which were prepared for the instruction of noncommissioned officers. A small edition was published by request for use of noncommissioned officers of the Philippine Department, where the author was then on duty. Since that time three editions of several printings each have been published. Each edition was an effort to revise the text to meet conditions pertaining to the instruction of junior officers, and of noncommissioned officers at the time of writing. Such is the case with this, the fourth edition.

No originality is claimed as regards the subject matter of this text other than its arrangement, and the simple methods of illustrating the basic principles which have been developed at the General Service Schools and published from time to time in pamphlet form for the information of the army.

The text includes eight lessons in map reading, ten lessons in sketching, and five lessons in panoramic sketching. It also outlines a training camp schedule of five lessons in map reading and five lessons in sketching. The simple methods set forth in the various lessons are such as the author has found to be the most practicable after years of experience as an instructor at the General Service Schools, garrison schools and training camps.

This revision brings the text up to the minute, including the new system of scales recently authorized by the War Department, coordinates, and the developments in aerial photography and map reproduction.

Introduction

The idea seems to be general that the World War brought about many changes in the subject of Military Topography, but, after the final analysis, we find that the only changes are the following:

1. The general use of coordinates in locating points, lines and areas.

2. The introduction of a new system of scales for military mapping.

3. The development of aerial photography.

For some unknown reason coordinates were never generally used in our military service until the World War. The close cooperation of infantry and artillery in modern military operations renders the precise location of objectives a vital necessity, and we simply caught step with our allied forces in that respect, and now marvel as to why some system of location by coordinates was not generally introduced into our service many years before.

The following from Army Regulations (Maps and Mapping) now governs as to scales and contour intervals:

> 12. SCALES.—The use of maps of scales larger than 1: 20,000 for general military purposes is to be discouraged, and such maps will not be used in training unless specially authorized by the War Department. When, however, for special purposes it becomes necessary to show detail which can not be shown on maps to 1: 20,000 scale, either 1 : 10,000 or 1 : 5,000 may be used. Except for some engineering and construction purposes, maps of scale larger than 1 : 5,000 will rarely, if ever, be needed by the military forces. In general, the various scales will be used as follows:
>
> *a. 1: 62,500.*—For route maps of extended marches, or of marches of large commands using several roads.

b. 1:20,000.—For ordinary route sketches and extended marches, or of marches of large commands using several roads.

c. 1:10,000.—For position and outpost sketches.

d. 1:5,000.—For maps used in the war game, discussion of operations at maneuvers, and in siege operations.

13. CONTOUR INTERVALS.—Contour intervals will be such as to show the maximum delineation of the ground consistent with cartographic clearness and will be in some multiple of 5 feet. In moderately rolling country the standard system of scales and contour intervals, which will give good delineation of the ground and at the same time cartographic clearness and facility in reading, is as follows:

	Feet.
1/62,500, vertical interval, normally	20
1/20,000, vertical interval	20
1/10,000, vertical interval	10
1/5,000, vertical interval	5

We have many valuable maps, scale 3″=1 mile, and 12″=1 mile, which have been used for training purposes in the past, and, without doubt, will be so used in the future, especially the Leavenworth and Gettysburg maps. In view of this fact, the text explains both the old and new systems of scales and contour intervals. In each case the scales and contour intervals are worked out on a normal system, and the M. D. (Map Distance) for any degree of slope may be determined by the same old formula,

$$\text{M. D.} = \frac{688 \quad \text{R. F.} \times \text{V. I}}{\text{Angle of Slope.}}$$

The series of lessons outlined in this book have been evolved from years of experience in instructing junior officers and noncommissioned officers in garrison schools, as instructor at numerous training camps, at the General

Service Schools, and as senior instructor at National Guard Camps.

There seems to be a difference of opinion as to the time necessary to acquire a working knowledge of map reading or of military sketching. It is believed that the average noncommissioned officer can cover the subject in most cases about as quickly as the college man, as there is nothing abstruse about the subject. It can not be disputed that a clever instructor can throw a considerable light on the subject of map reading in one short lecture, but, nevertheless, if those who are now thoroughly familiar with the subject will hark back and review their own experience in mastering the subject, it is believed that all will agree that ten lessons of two hours each in map reading and the same period of time for sketching is a reasonable time to master the subjects deliberately and methodically. However, the lessons are so arranged that, by proper selection, courses may be outlined which will meet with almost any time conditions; see Part IV, for example, which outlines a shorter course for training camps.

PART ONE

Lesson I

Orientation, Distance, Direction

The first step in the actual use of a map in the field is to see that all locations on the map are in the same relative position as they are on the ground. This step is called, "Orienting the map."

A straight line joining your position on the ground and the North Pole of the earth is called the *True Meridian,* while a straight line coinciding with your compass needle is called the *Magnetic Meridian.* The directions of the needle at different places on the earth's surface converge approximately toward the magnetic poles of the earth. These poles do not coincide with the poles of the earth's axis, and therefore the magnetic and true meridians do not generally coincide.

The angle between the magnetic and true meridian at any place is called the "Declination of the needle" for that place.

There is a certain irregular line on the earth's surface at all points of which the true and magnetic meridians coincide and the declination is zero. This line is called the "agonic" line. In the United States it passes in a southeasterly direction from Michigan through intervening states to South Carolina. The agonic line is not permanent, but is slowly moving westward. At all points in the United States east of the agonic line, the north end of the needle inclines to the west of the true meridian. To the west of the agonic line the needle inclines to the east of the true meridian.

Isogonic lines are lines joining points of the same declination of the needle. As the agonic and isogonic lines are gradually changing, maps should always have the true as well as the magnetic meridian indicated.

There are a few simple methods of determining the true meridian (true north and south line) with a degree of accuracy sufficient for military sketching and map reading.

For an accurate instrumental survey, an observation on Polaris (North Star) should be taken. This is not included in the text, as it properly comes under the head of advanced surveying.

First Method

By Means of the North Star.—Without instruments, it can be determined approximately by placing two cords, with weights attached, in line with the star. The cords should be about 12 feet apart, and to see the forward one, it will be necessary to throw a light upon it. This line can readily be prolonged by daylight.

Second Method

By Aid of the Sun and Plumb-Bob (see Fig. 1).—On a level piece of ground lean a pole toward the north, and rest it in a crotch made by two sticks as shown. Suspend a weight from the end of the pole so that it nearly touches the ground; then, about an hour before noon, attach a a sharpened stick attached to the other end of the string,

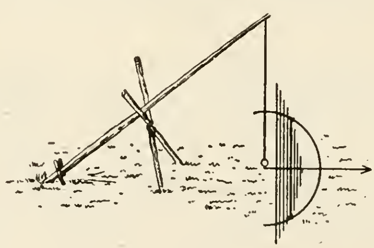


Fig. 1

describe an arc with a radius equal to the distance from the peg to the shadow of the tip of the pole. Drive a peg on the arc where the shadow of the tip of the pole rested. About an hour after noon watch the shadow of the tip as it approaches the eastern side of the arc, and drive another peg where it crosses. By means of a tape or string, find the middle point of the straight line joining the last two pegs mentioned. A straight line joining this middle point and the peg under the weight will be in the true meridian. Place a pole about a hundred yards in

prolongation of this line, and with the compass sight back on the tip of the inclined pole, and the declination will be obtained.

Third Method

By Aid of the Watch and Sun.—Lay the watch on some level surface and revolve it until the hour hand points directly under the sun. Then by reference to the divisions on the dial, determine a point on it midway between the hour hand and twelve o'clock. A line through this point and the pivot of the hands will be approximately in the true meridian. (See Fig. 2.)

The operation of pointing the hour hand directly under the sun is made easy by casting the shadow of a vertical

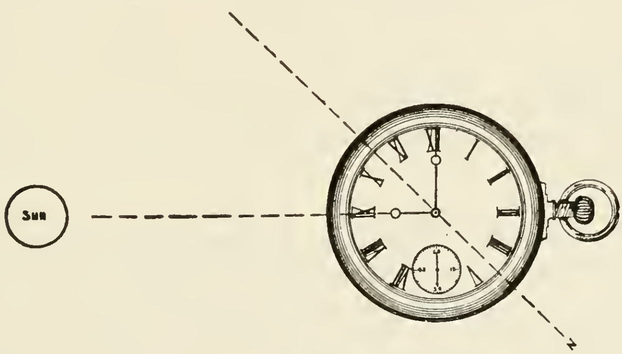


Fig. 2

straight stick across the face of the watch and then bringing the hour hand into this shadow.

The watch method will not answer during certain seasons in the tropics when the sun passes directly overhead.

There is also another slight error due to the fact that in some sections there is a difference of half an hour between standard and sun time.

ORIENTING THE MAP

As heretofore stated, all complete maps have both the true and the magnetic meridian indicated. However, it is assumed that you have found the declination of the needle for your particular locality, so, if either the true or the

magnetic meridian be given, the other can be readily determined.

1. Suppose that you have the true meridian indicated on your map, but no magnetic meridian given. Determine the declination of the needle by one of the methods outlined above, or better yet, when you first go to a new locality ascertain from reliable sources what the declination of the needle is for that particular locality. Draw a magnetic meridian on your map. Then place your compass on the map so that its needle pivot is on the arrow indicating the magnetic meridian. Turn the map horizontally to the right or left, as may be necessary, until the north end of your compass needle and the magnetic meridian point in the same direction. Your map is then oriented. If the magnetic meridian is already on the map, simply place the compass on the map and proceed as outlined above.

2. If neither meridian is indicated on your map, there are still several ways that it may be oriented, as for example:

(*a*) Draw a straight line through any two map positions that you can identify on the ground. Turn the map until the line joining the map positions is in the same relative position as the line joining the ground locations. Your map is then oriented. The orientation will be more accurate if one of the map positions is your ground position, thus affording an opportunity to sight along the lines.

(*b*) By placing the map so that roads, railroads, or any other well-defined lines on the map are in the same relative position as you see them on the ground.

How to locate your ground position on the map, assuming that your map is oriented:

1. By observation, considering your position relative to some conspicuous point on the ground that you can locate on the map.

2. When the first method can not be done with a sufficient degree of accuracy, then you must depend upon the simple process of *Resection,* which is as follows:

Orient your map. Locate two conspicuous points on

the ground that are given on your map. Pivot your ruler on one of the map positions, and sight towards its ground position. Draw a straight line toward your body. Repeat the process with the other point. The intersection of the two lines is your map location.

In order to insure accuracy, the intersection of the two lines should form an angle of from 60 to 120 degrees, otherwise the two intersecting lines are becoming more and more parallel, so that it is difficult to locate definitely the point of intersection. It is well to remember this principle, as it is applied frequently in sketching. It sometimes happens that one of the intersecting lines is already drawn, as, in the event that you are on a straight road or some other well-defined line located on your map.

MAP DISTANCES

It is very clear that the ground and all of the objects upon it can not be represented on the map as large as they actually are. All measurements must be reduced to the minimum consistent with the purpose the map is to serve. In other words, map distance is always a certain fractional part of the corresponding ground distance, as, for example: 1/20,000, 1/10,000, or 1/5,000, meaning that one inch, foot, centimeter, meter, yard, etc., on the map is equal to 20,000 or 10,000 of similar units on the ground. This relationship between map distance and ground distance is called the scale of the map.

The scale of a map may be expressed in several ways, as, for example:

1. By a simple statement, such as: Three inches equal one mile, or three inches to the mile.

2. By an equation, such as: $3'' = 1$ mile.

3. By a fraction, such as: 1/20,000, 1/10,000, 1/5,000, 1/62,500 which are some of our standard scales. When the scale is expressed in the form of a fraction, it must be remembered that both numerator and denominator are of the same denomination.

4. Graphically, by placing on the map a line divided into a certain number of equal parts, each division being marked by the distance it represents on the ground.

Knowing the scale of our map and having oriented it, we should now be able to determine from the map the distance between objects on the ground and the direction of one from another.

We will first consider converting map distance into ground distance. Every complete map has a reading scale of some well-known unit as yards or miles, so all that is necessary to determine the ground distance between points on the map is to apply the reading scale to the map distance or the map distance to the reading scale.

The construction of reading scales will be taken up in Lesson X. However, it will rarely happen that the party reading the map will find it necessary to construct a reading scale.

There are several simple methods of determining distance on the map:

1. Assume that you have no reading scale except the one printed on the map. If such is the case, mark the distance to be measured on a straight-edged piece of paper, and apply the paper to the reading scale on the map.

2. If your map happens to be on a scale of a certain number of inches to the mile, apply a scale of inches along the line to be measured, and divide the distance measured off by the number of inches to the mile given on the scale of the map. (Caution: Do not confuse the terms "Miles per inch" and "Inches per mile.")

3. The Geological Survey maps on a scale of 1/62,500 are in general use in connection with military operations, but, as there is a difference of only about one per cent between these maps and maps made on the scale of one inch equals one mile, the one inch reading scale is sufficiently accurate for many purposes.

4. The Map Measurer. This is an instrument so constructed that it may be rolled over the surface of a map, and will record on a dial the distance passed over. It is a very convenient and efficient instrument in connection with war games which are played on a large scale map.

MAP DIRECTION

As the captain consults his chart and compass in guiding his ship, so must the soldier consult his map and compass in traveling through unknown regions.

There are many varieties of compasses, all quite similar. All have the cardinal points, N, E, S and W (North, East, South and West) marked on the face, as well as circular graduations from 0 to 360 degrees, usually clockwise from the north point. In order to travel by the compass, one must be able to convert map directions into compass directions; in other words, we must be able to determine the *Magnetic Azimuth* of any line.

By the term azimuth is meant the horizontal angle that a line makes with either meridian, measured clockwise from the meridian. If measured from the true meridian, it is called the true azimuth, and, if measured from the magnetic meridian, it is called the magnetic azimuth.

A protractor is an instrument for measuring and plotting angles. There are several varieties, viz.: circular, semi-circular and rectangular, the graduations in degrees varying with the type of protractor.

The following will illustrate the use of the rectangular protractor:

You are at the point *A*, Fig. 3, and you wish to obtain the magnetic azimuth of the line *AB*. Draw a line *AC* through *A* parallel to the magnetic north and south line. Lay your protractor along *AC*, the center of the protractor at *A*. (The center of the protractor is indicated by an arrow point.) Read the number of degrees between *AC* and *AB*. It is found to be 63 degrees, which is the magnetic azimuth of the line *AB*.

Then suppose that you are at *A*, and wish to proceed in the direction of *B*. Simply hold the compass so that the needle is at *N*, then follow in prolongation of a line drawn through the pivot of the needle and the 63-degree point. The course is kept by an occasional reference to the compass which is held in front of you or placed upon the ground.

Maps of various scales should be issued to members of the class, who should determine the distance in terms of

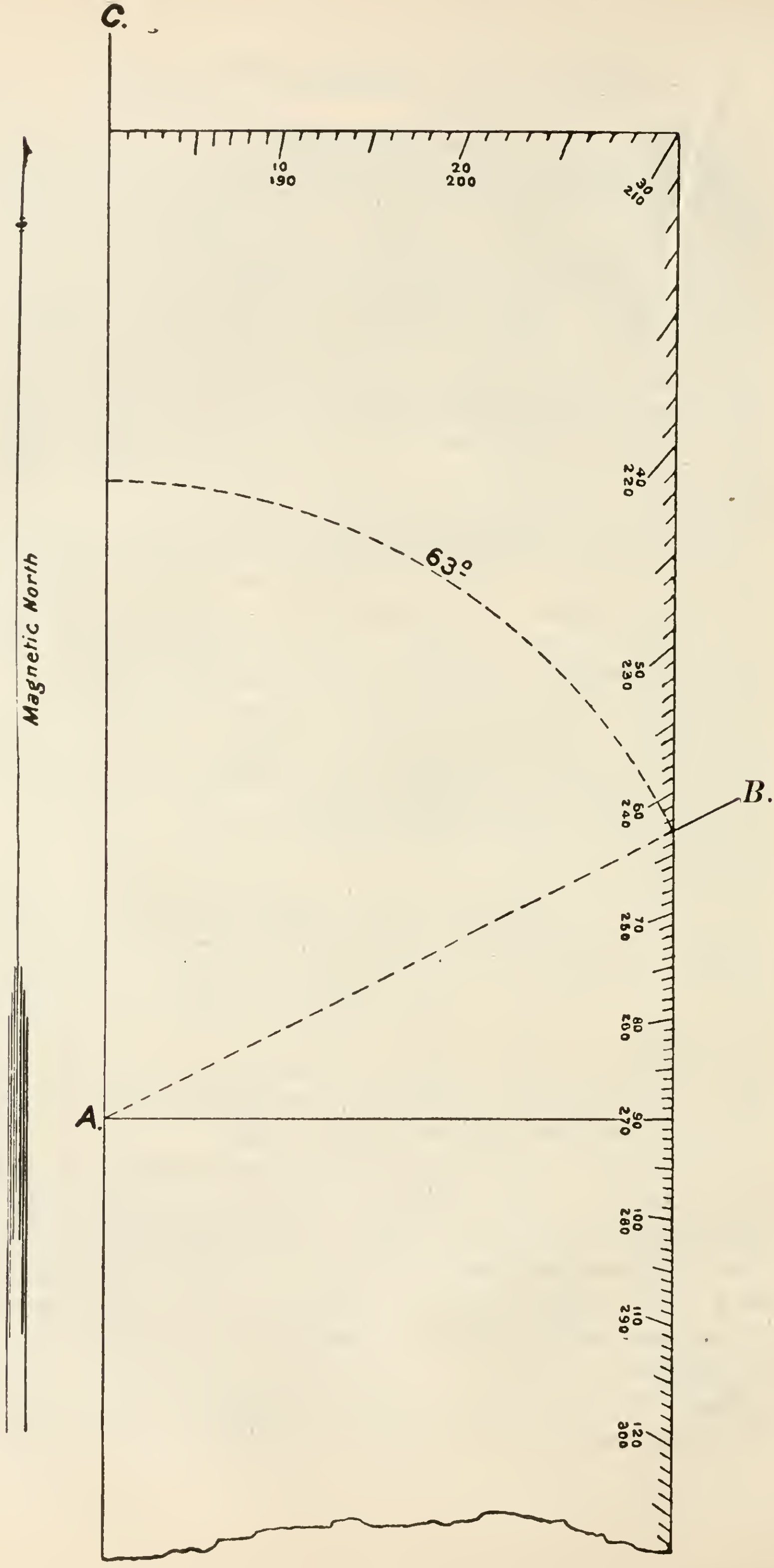

C.
A.
B.
Magnetic North
63°
10
190
20
200
30
210
40
220
50
230
60
240
70
250
80
260
90
270
100
280
110
290
120
300

Fig. 3

yards, miles, or paces, and the magetic azimuth between designated points in accordance with instructions given in this lesson.

While this lesson can be conducted very efficiently indoors, it is best, if practicable, to take the class to some good viewpoint on the ground, and practice orientation under the various conditions outlined. The estimation of distance may be brought in very nicely in connection with scaling off distances on the map. See that every member of the class actually applies the principle of resection. Have them determine the azimuth of various conspicuous points on the ground that are given on the map. It is believed that, by two hours of methodical field instruction, the average soldier will thoroughly understand the basic principles of map reading as outlined in this lesson.

QUESTIONS FOR REVIEW

1. What is meant by the expression, "Orienting the map"?
2. What is meant by the true and magnetic meridians?
3. What is meant by the declination of the needle?
4. What is the agonic line?
5. What is the isogonic line?
6. Where is the declination of the needle to the east of the agonic line? To the west?
7. Describe three methods of determining approximately the true meridian.
8. Describe two methods of orienting the map.
9. Describe two methods of locating your position on the map.
10. What is meant by the scale of a map?
11. In what ways may the scale of a map be expressed?
12. Describe the methods of scaling distances on the map.
13. What is meant by the magnetic azimuth of a line? The true azimuth?
14. What is a protractor?
15. Describe the use of the protractor in determining the true and magnetic azimuth of a line.
16. Practical problems pertaining to orientation distance and direction should be given to the class.

Lesson II

Conventional Signs

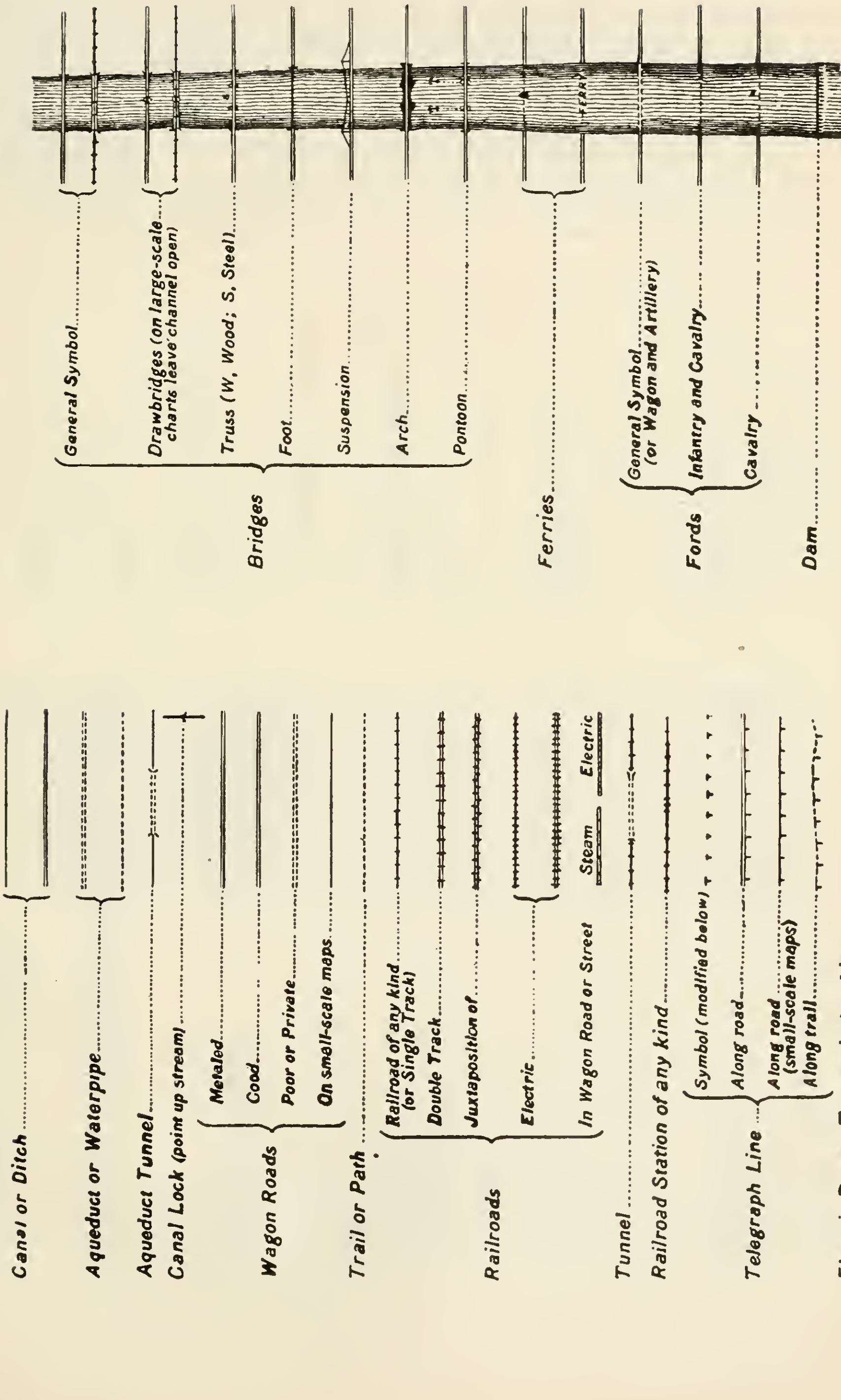
Having learned how to orient the map and to read distances and directions on the map, we will now consider the many natural and artificial ground features of importance and the method of representing them on the map.

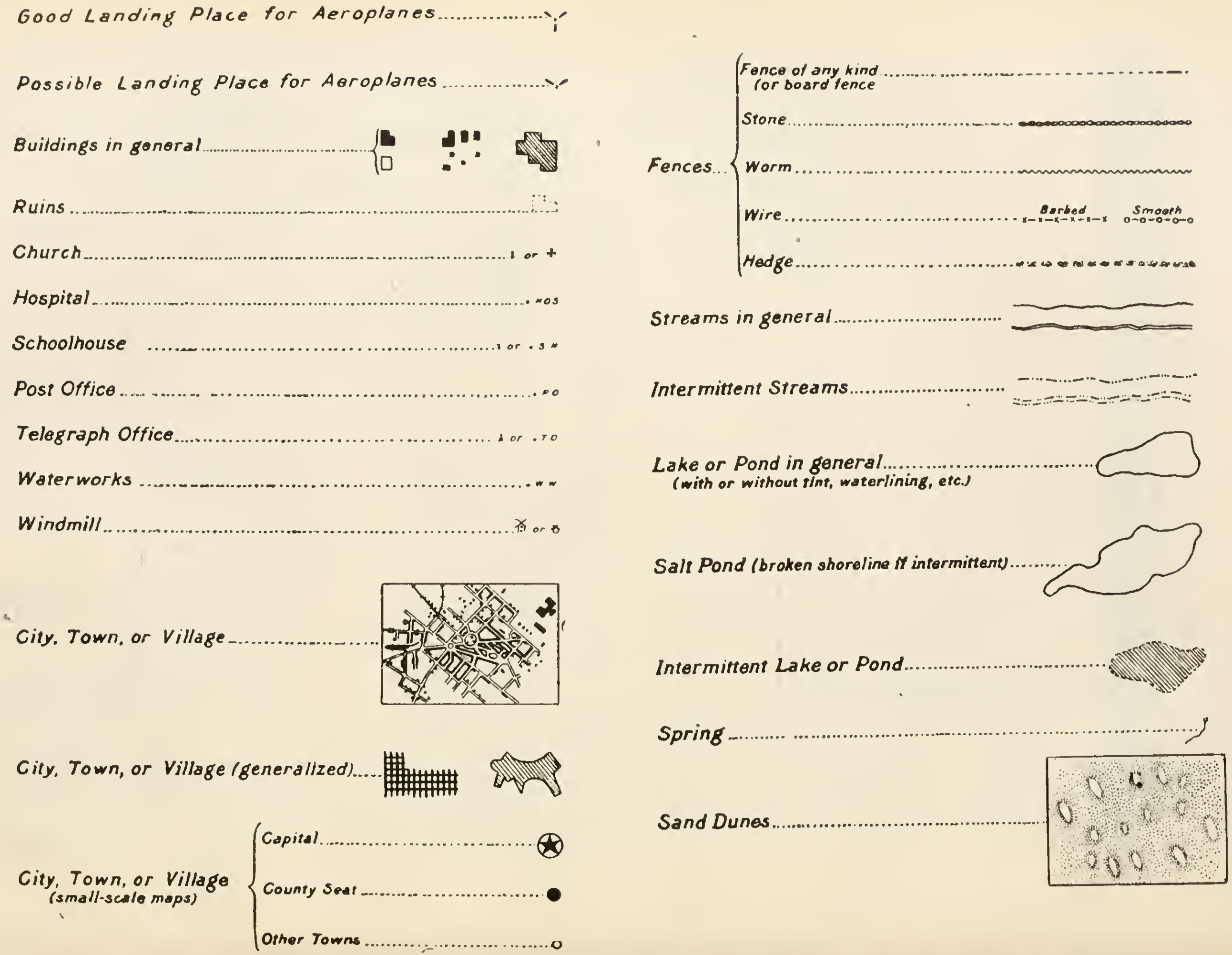
In order that all may be able to read the map when completed, we must have some fixed method of representing these ground features. With this in view the United States Geographic Board has adopted a system of conventional signs for the use of all map-making departments of the government. At the close of the lesson are those that pertain to the work to be covered by this book. Members of the class should be required to reproduce these signs as neatly as possible, and this lesson should be devoted to that purpose.

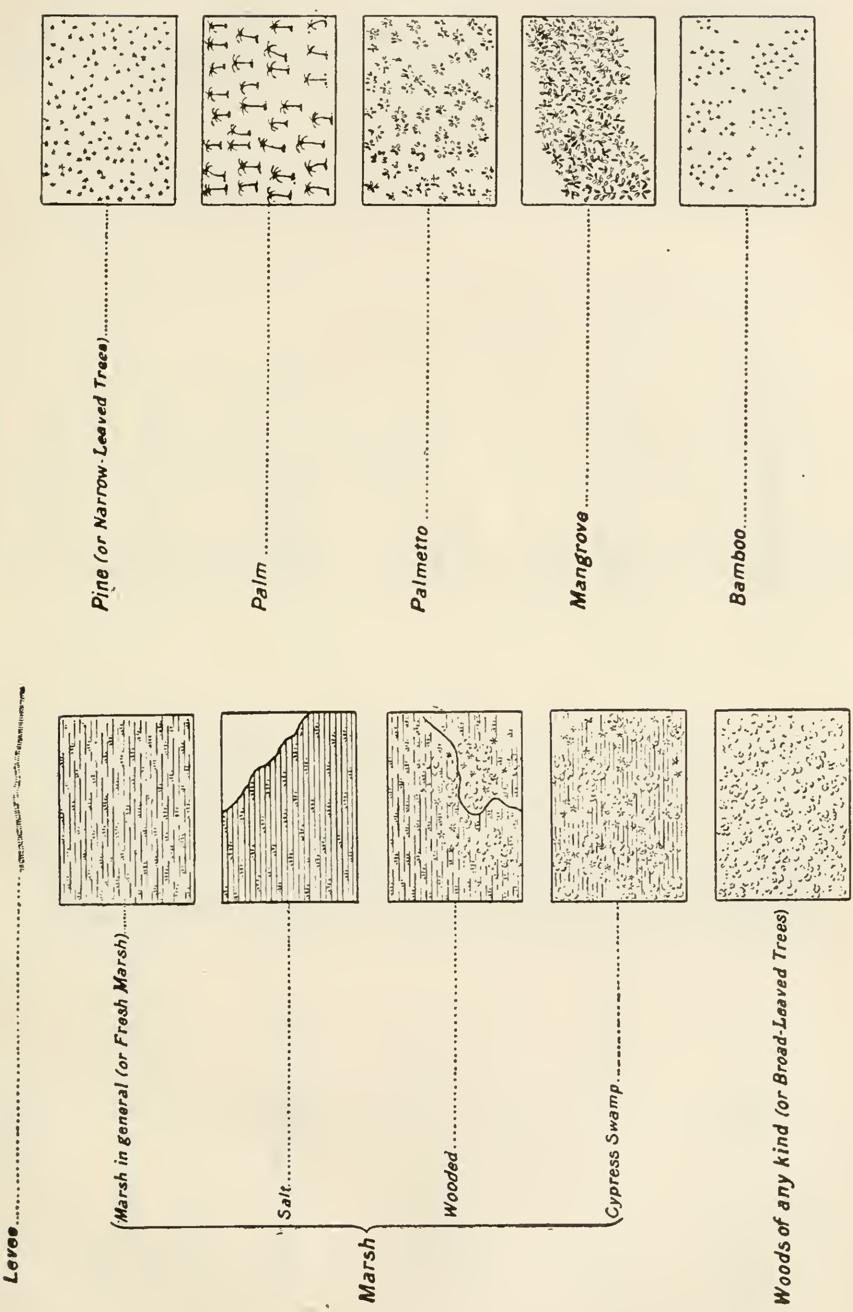
The instructor should superintend and criticise the work; especially should he avoid the usual tendency of making the signs too large. The ability to reproduce conventional signs neatly should be included in the examination over this subject. When you find some idle moments with a pencil and paper at hand, your time may be profitably employed by practicing the construction of conventional signs.

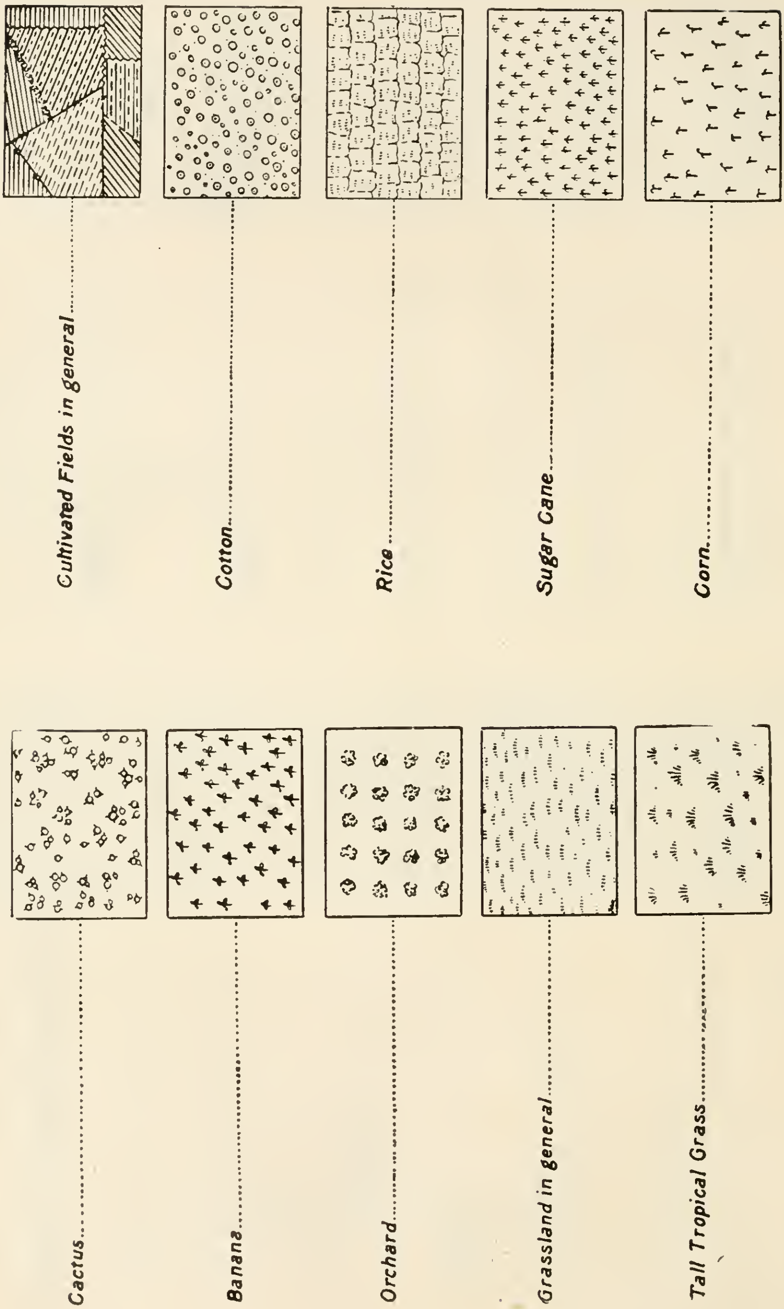
Just a few words about pencils would not be amiss at this particular point.

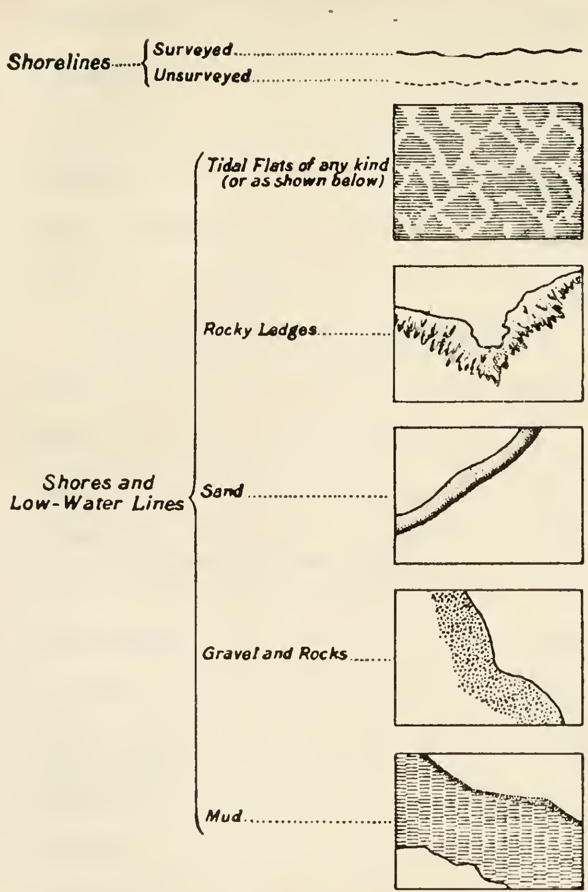
The best for plotting are the hard kinds corresponding to Faber's Siberian HHHH and HHHHHH, especially for drawing fine lines and making points. For most kinds of work, a sharp-pointed pencil is used. For drawing long, straight lines, a chisel-pointed pencil should be used to produce a line of uniform breadth. For sketching and filling in conventional signs, softer pencils are preferable, such as correspond to Faber's HB. To keep the point always in good condition one should have a piece of fine sandpaper at hand for that purpose, being

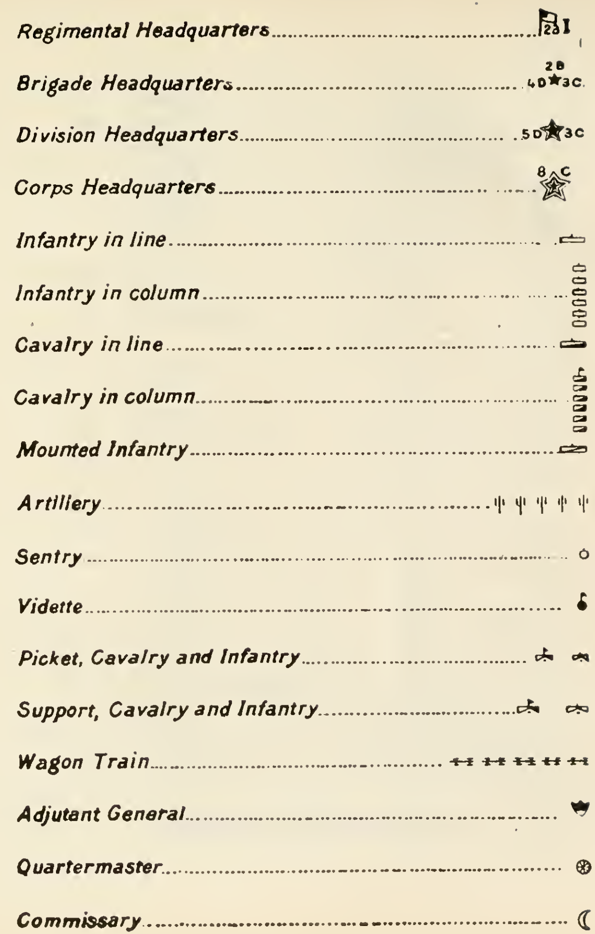

Canal or Ditch
Aqueduct or Waterpipe
Aqueduct Tunnel
Canal Lock (point up stream)
Wagon Roads
Metaled
Good
Poor or Private
On small-scale maps
Trail or Path
Railroads
Railroad of any kind (or Single Track)
Double Track
Juxtaposition of
Electric
In Wagon Road or Street
Steam
Electric
Tunnel
Railroad Station of any kind
Telegraph Line
Symbol (modified below)
Along road
Along road (small-scale maps)
Along trail
Electric Power Transmission Line
Bridges
General Symbol
Drawbridges (on large-scale charts leave channel open)
Truss (W, Wood; S, Steel)
Foot
Suspension
Arch
Pontoon
Ferries
FERRY
Fords
General Symbol (or Wagon and Artillery)
Infantry and Cavalry
Cavalry
Dam


Good Landing Place for Aeroplanes
Possible Landing Place for Aeroplanes
Buildings in general
Ruins
Church
or
Hospital
HOS
Schoolhouse
or
S H
Post Office
P O
Telegraph Office
or
T O
Waterworks
W W
Windmill
or
City, Town, or Village
City, Town, or Village (generalized)
City, Town, or Village
(small-scale maps)
Capital
County Seat
Other Towns
Fences
Fence of any kind
(or board fence
Stone
Worm
Wire
Barbed
Smooth
Hedge
Streams in general
Intermittent Streams
Lake or Pond in general
(with or without tint, waterlining, etc.)
Salt Pond (broken shoreline if intermittent)
Intermittent Lake or Pond
Spring
Sand Dunes


Pine (or Narrow-Leaved Trees)
Palm
Palmetto
Mangrove
Bamboo
Levee
Marsh in general (or Fresh Marsh)
Salt
Wooded
Cypress Swamp
Marsh
Woods of any kind (or Broad-Leaved Trees)


Cultivated Fields in general
Cotton
Rice
Sugar Cane
Corn
Cactus
Banana
Orchard
Grassland in general
Tall Tropical Grass


Shorelines
Surveyed
Unsurveyed
Shores and
Low-Water Lines
Tidal Flats of any kind
(or as shown below)
Rocky Ledges
Sand
Gravel and Rocks
Mud


Regimental Headquarters
Brigade Headquarters
Division Headquarters
Corps Headquarters
Infantry in line
Infantry in column
Cavalry in line
Cavalry in column
Mounted Infantry
Artillery
Sentry
Vidette
Picket, Cavalry and Infantry
Support, Cavalry and Infantry
Wagon Train
Adjutant General
Quartermaster
Commissary

Medical Corps

Ordnance

Signal Corps

Engineer Corps

Gun Battery

Mortar Battery

Fort } *True plan to be shown if known*
Redoubt }

Camp

Battle

Trench

When color is used execute the following in red

Abattis

Wire Entanglement

Palisades

Contact mines

Controlled mines

Demolitions

AUTHORIZED ABBREVIATIONS

A.	Arroyo	L.S.S.	Life Saving Station
abut.	Abutment	L.H.	Lighthouse
A.	Arch	Long.	Longitude
b	Brick	Mt.	Mountain
B. S.	Blacksmith Shop	Mts.	Mountains
bot	Bottom	N.	North
Br.	Branch	n f.	Not fordable
br.	Bridge	p.	Pier
C	Cape	pl..	Plank
cem.	Cemetery	P. O.	Post Office
con	Concrete	Pt	Point
cov	Covered	q.p.	Queen-post
Cr.	Creek	R.	River
cul.	Culvert	R H.	Roundhouse
D. S.	Drug Store	R R.	Railroad
E.	East	S	South
Est.	Estuary	s.	Steel
f.	Fordable	S. H.	School House
Ft.	Fort.	S. M.	Saw Mill
G. S.	General Store	Sta.	Station
gir.	Girder	st.	Stone
G. M.	Grist Mill	str.	Stream
i.	Iron	T. G.	Toll Gate
I.	Island	Tres.	Trestle
Jc.	Junction	tr.	Truss
kp.	King-post	W. T.	Water Tank
L.	Lake	W. W.	Waterworks
Lat.	Latitude	W.	West
Ldg.	Landing	w.	Wood

careful to remove any lead dust from the point before using. More depends upon the proper sharpeneing of a pencil, and afterwards keeping it so, than is commonly supposed.

Most drawings to be inked are first constructed in pencil, the lines being made with as little pressure and as fine as is possible to show distinctly.

As a test, the instructor should select twenty-five conventional signs in common use, and give the class about fifteen minutes to draw them. With due allowance for correctness of symbols and neatness, the papers may be very quickly graded. The student should also study his map carefully, and be able to identify all conventional signs noted thereon.

Lesson III

Contours

We have learned how to determine from the map the horizontal distance between points on the ground, the direction of one point from another, and the conventional signs representing the various ground features, but, in order to furnish the commanding officer of troops in the field the necessary information relative to grades of roads, visibility of his troops to hostile land forces, fire direction, and the effects of hostile fire, there must be some method of rapidly determining elevations from the map. In other words, we must know how high the hills are, how deep the valleys are, etc. These relative elevations are shown by lines called *contours*.

The standard definition of contour lines is: lines cut from the earth's surface by imaginary horizontal planes at equal vertical intervals.

Picture in your mind some small island that you have seen. Imagine that the island is completely submerged due to high water, and, by a series of falls, the water line drops ten feet at a time, remaining long enough after each drop to deposit a line of silt along the water level. The various silt lines would be accurate contour lines of the island with a vertical interval between contours of ten feet. Now suppose that the silt lines would all drop down to a level surface like the hoops of a barrel dropping to the floor. You would then have an accurately contoured map of the island. See Fig. 4.

Another method of illustrating contours is by means of a large rutabaga (Swedish turnip). Cut it in half, preferably from the top toward the root, and place one half on a level surface. You then have a good representation of an island. See Figure 5-*a*.

Next, cut the rutabaga into several smaller slices at equal vertical intervals, and place the slices together in their original formation on a piece of paper. See Figure 5-*b*.

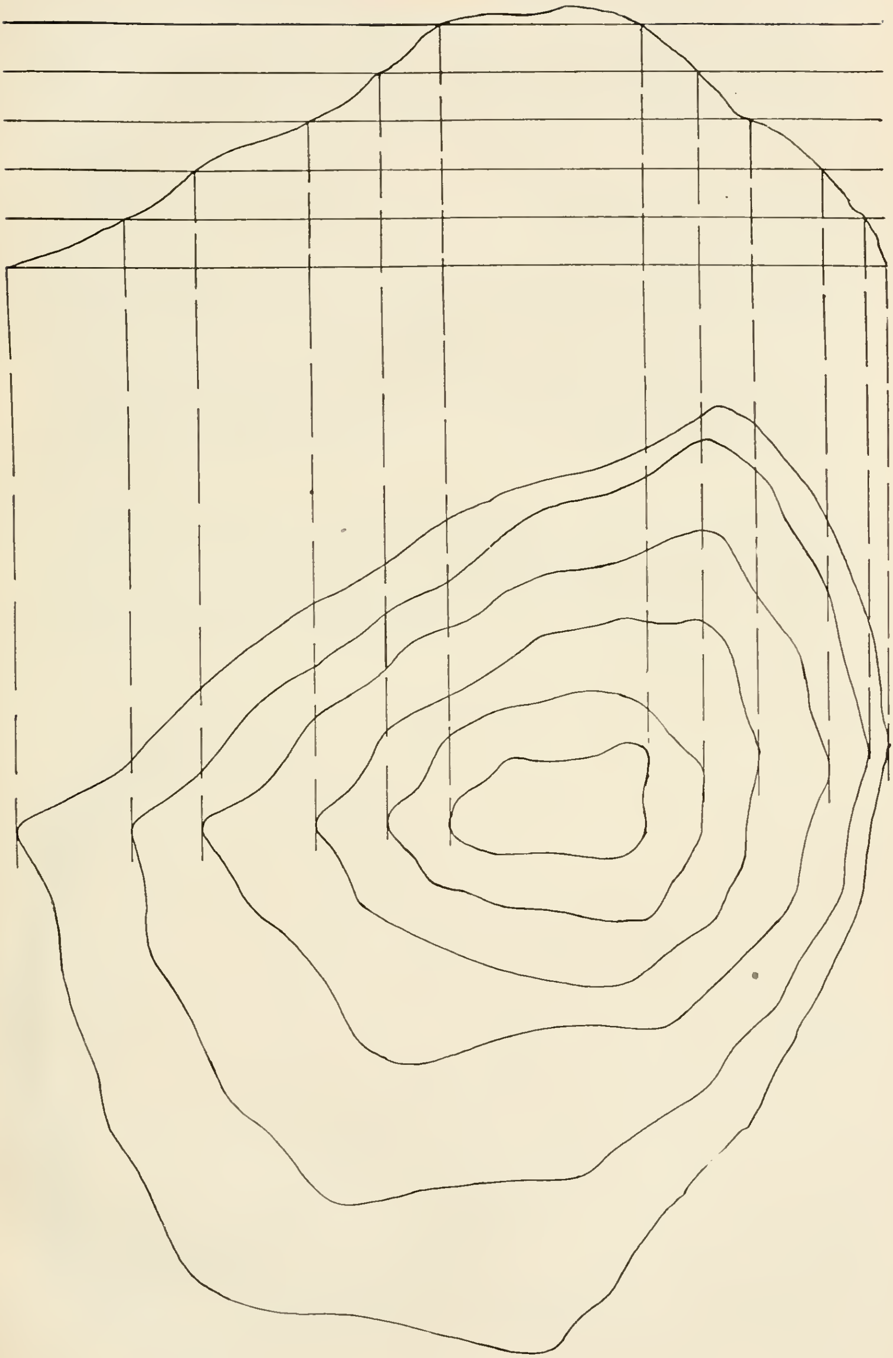


Fig. 4.

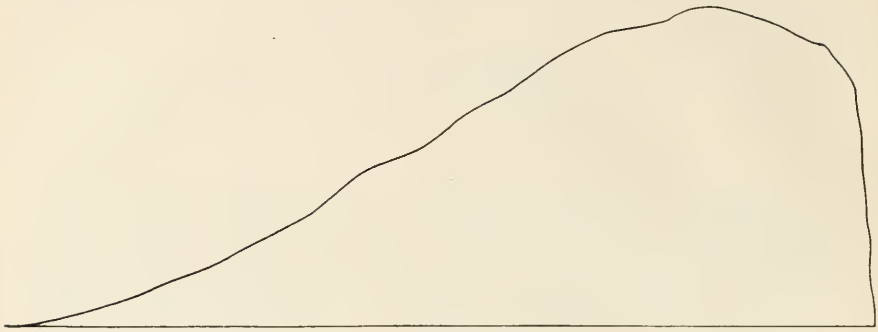


Fig. 5-a

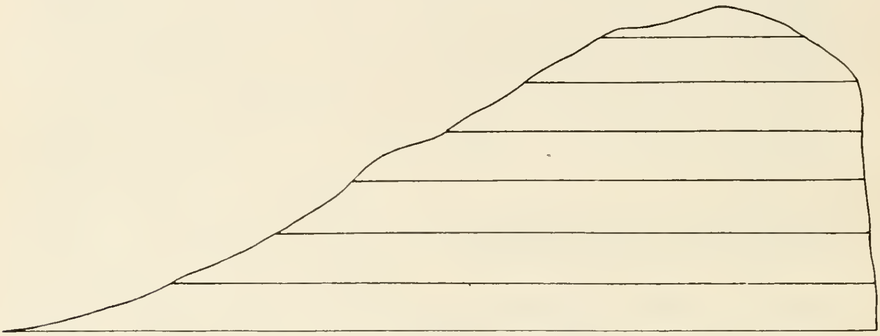


Fig. 5-b

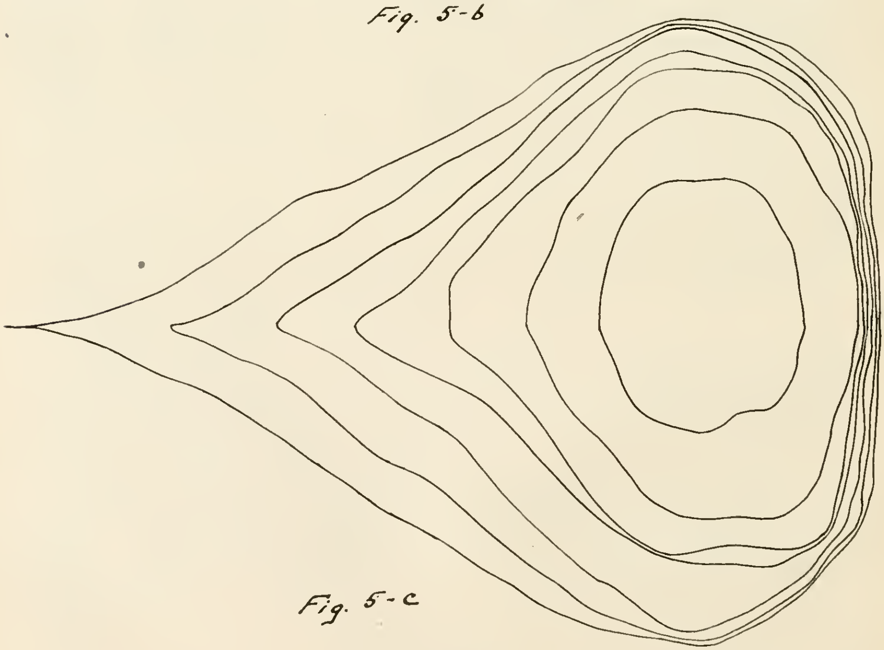


Fig. 5-c

Then, with a soft pencil, draw a line around the lower margin of the lowest slice. Remove the lowest slice, and repeat the process with each successive slice after it is dropped perpendicularly to its relative position on the paper. See Figure 5-*c*.

Next, if practicable to do so, the instructor should issue to each member of the class a well-contoured map of the local terrain. Each student should be equipped with three colored pencils, as for example, red, green and blue. Now assume that the lowest contour on the map reads 380 feet and the highest 720 feet. Trace over in red all areas below 500 feet, in green all areas between 500 and 600 feet, and in blue all areas over 600 feet. This affords the beginner an excellent opportunity to become familiar with reading contours.

Take the class to some high point on the local terrain, and let each student, under general supervision of the instructor, compare the map with the ground as to the various features of the relief.

Lesson IV

Relief Maps

With many individuals and with some classes it may be impracticable to pursue the lessons pertaining to relief maps, due to a lack of time or to the lack of funds to purchase the necessary paraphernalia, but, wherever practicable, it is urgently advised that this work be taken up as it will absolutely clarify the whole subject of map reading and especially the subject of contours, as well as being of the greatest value in the study of the closely allied subject, Minor Tactics.

The method of construction of relief maps about to be described is a decided departure from previous methods. Instead of the sand box, moulder's wax, or plastilina, is used. It is the same material used by school children for modeling purposes. This material lends itself admirably to this class of work due to the fact that it is very plastic, retains its consistency, and when the relief map is completed, it permits a vivid representation of all terrain features by means of indentations in the wax.

In order to be successful in this work the moulder's wax must be used. The sand table answers the purpose very well for indoor work in field fortifications or to illustrate certain ground formations in a crude way, but it will not do for topographical work. Every organization and military institution should secure enough of the wax for relief map construction in connection with map reading and instruction in Minor Tactics.

Construction of Relief Maps

The first necessity is a table constructed as shown in Fig. 6. The two enclosures on top of the table are 18″ square, interior measurements (the same dimensions as the Gettysburg-Antietam 12″ sheets). The flange enclosing the squares is one-fifth of an inch thick and an inch and a half in width. The top of the table should

be perfectly level, and the flange of uniform thickness and planed. Also secure a rolling pin of hard wood, 22″ long and about 4″ in diameter. A sufficient amount of moulder's wax or plastilina should be secured. This may be purchased from Stewart & Company, 24 Broadway, New York City, and presumably from other dealers. The wax comes in different colors; the olive-green is preferable for this work. It takes about twenty pounds to construct one of the Gettysburg-Antietam 12″ sheets, but is well worth the investment.

As, without doubt, you will have need to use the Gettysburg-Antietam 12″ sheets in connection with

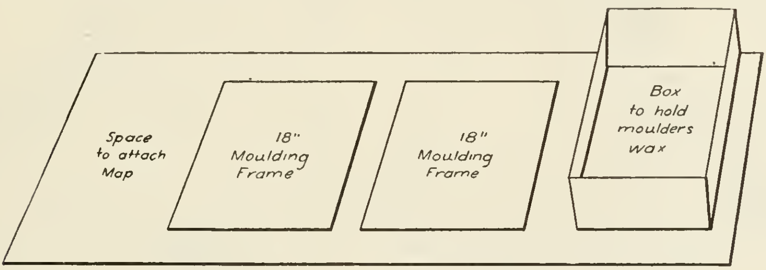


Fig. 6

studies of minor tactics, let us construct a relief map of one of those sheets. The necessary 12″ sheets, unmounted, may be secured from the Book Department, General Service Schools, Fort Leavenworth, at a surprisingly cheap price.

The table, moulder's wax, and maps having been secured, the actual method of construction is as follows:

Place a sufficient amount of wax in each of the squares, and roll off flush with the top of the squares, so that you now have two sheets of wax each one-fifth of an inch thick. If the wax sticks to the tray and roller, apply a little talcum powder. Place the map over one of the squares, and, with a blunt stylus, trace over the lowest heavy contour (20 feet) on the map, leaving an impression of same on the wax. Cut out that portion of the wax the surface of which, according to the map, would be below the contour just traced. Take the remainder of the sheet

of wax and place it upon the base established in the other square. Refill the square from which the wax has just been removed, roll as before, and trace the next heavy contour. Continue this operation, which will result in an incomplete relief map similar to that shown in Fig. 8.

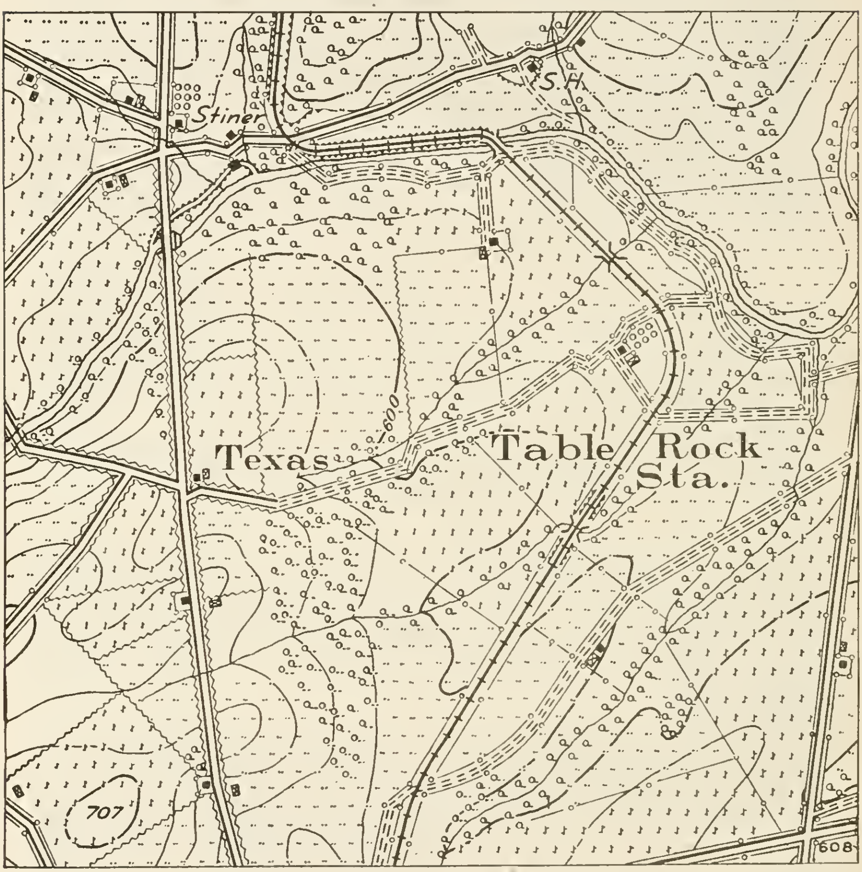


Fig. 7

Next, slope off abrupt surfaces between the heavy contours by moulding in small pieces of wax by hand, and the map is then completed in so far as the relief is concerned.

Next, all of the natural and artificial features of the terrain are represented by indentations in the wax. This is easily done by whittling out small, soft pine sticks to

represent the various conventional signs, as, for example, a square end stick for buildings, a round end for trees, etc. Roads and railroads may be drawn in by means of a stylus and a straight-edge. Letters and figures may be drawn

Fig. 8

in, or, better, stamped in with rubber stamps or steel type. Every feature is easily represented, and quickly indented on the surface of the wax. When you have no further use for a particular relief map, it may be torn up and another

one constructed from the same material. Fig. 9 represents the completed relief map.

With the mechanical means explained above, the student is absolutely sure of constructing the relief map correctly.

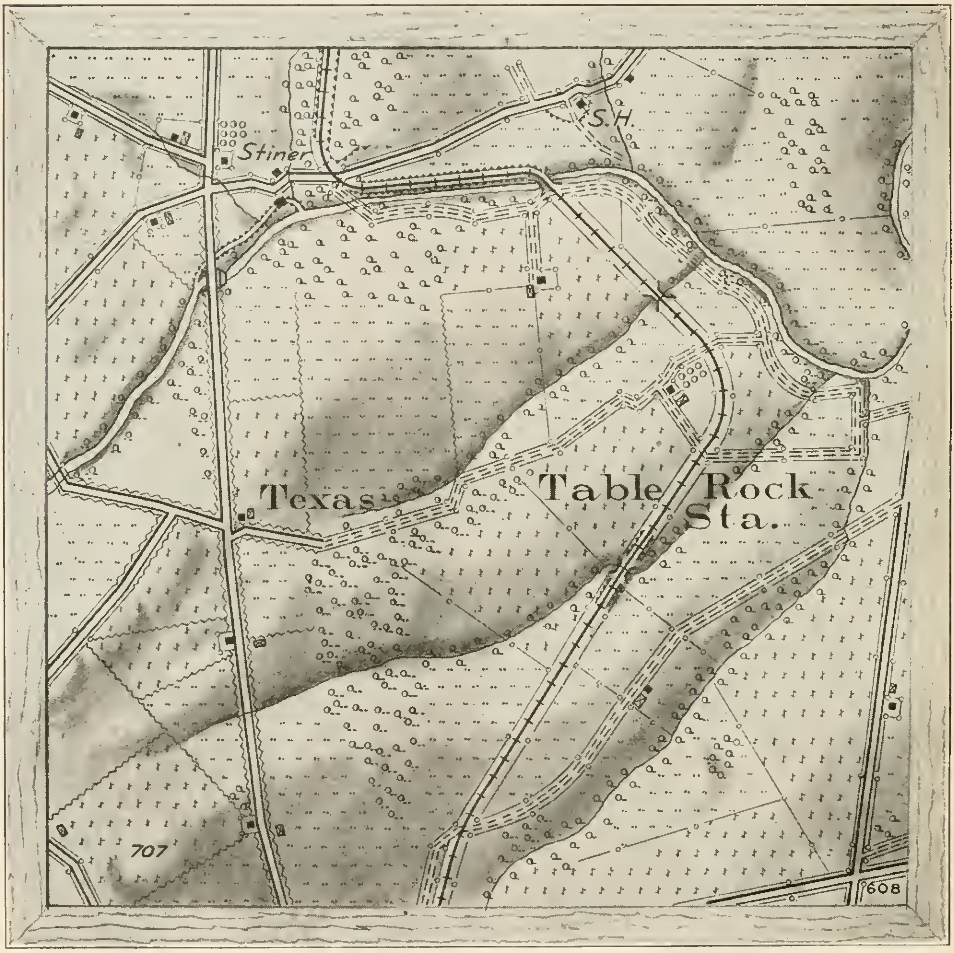


Fig. 9

Having done this work, it follows automatically that he is able to read a military map.

The following principles of contouring may be noted in connection with Fig. 9:

1. That all points on a contour line have the same elevation above the datum plane.
2. That, where the contours are equally spaced, the slope is uniform.
3. That, where contours are straight and evenly spaced, the ground is a sloping plane.
4. That the contours of a vertical surface lie on top of one another as in palisades.
5. That, if the slope in rocky formations is over the base, then only can contours cross.
6. That every contour closes upon itself or extends entirely across the map.
7. That on water-sheds the contours are convexed toward the base of the slopes.
8. That in water courses the contours are convex toward the sources of the stream.
9. That contours far apart indicate gentle slopes.
10. That contours near together indicate steep slopes.

SUGGESTIONS TO INSTRUCTORS

As a knowledge of map reading goes hand in hand with the study of tactics, it is believed that a few words at this point regarding the coordination of the work would not be amiss.

It has been found that pleasing results with junior officers and noncommissioned officers may be obtained by constructing relief maps of the terrain involved in small tactical problems such as patrolling, observation posts, and other intelligence work suitable for the intelligence platoons of headquarters companies. In this connection the student will find the book entitled, "Scouting and Patrolling," by Colonel Waldron, and for sale by the U. S. Infantry Association, Washington, D. C., to be of great assistance. The work may be carried on up to include a battalion or squadron. Assume, for example, a problem in which a battalion detrains, advances, reconnoiters, attacks an enemy in position, pursues, halts for the night, establishes outposts, prepares and occupies a defensive position, withdraws therefrom and retreats. All of these dis-

positions may be clearly and vividly visualized by the beginner with the aid of a relief map, and his interest will be stimulated from the start.

The best 12″ maps (War Game Maps) are to be obtained from the Book Department, General Service Schools, Fort Leavenworth, Kansas. Purchase several sets of these maps, unmounted, of the Emmitsburg Quadrangle. The cost will be but a trifle, and you will need them in the construction of relief maps. For small tactical problems, write to the U. S. Infantry Association for a copy of "Minor Tactics." These are splendid problems, all developed at the Infantry School of Arms and solved on the Emmitsburg Quadrangle.

Officers detailed on duty with the National Guard or at educational institutions are advised to instruct their Sergeant-Instructors in the construction of relief maps in order that they may aid in supervising the work. Much interest and excellent results have been obtained at educational institutions and in the various schools for junior officers and the noncommissioned of the National Guard by the work outlined above.

Lesson V

Visibility

It is often necessary in military operations to determine from the map the visibility of a point, line or area from some position occupied by a hostile force, as, for example, can you see a certain bridge in hostile territory from your observation post? Can you observe the march of a hostile column? Can you observe the terrain over which a hostile force is deployed?

If the map is correct, the above information can be obtained very accurately, but it must be remembered that most maps have more or less minor errors in relief so that the visibility of points, lines or areas can not be determined to the degree of accuracy that many may assume; also the natural and artificial features upon the earth's surface interfere in many cases, so, when there is a reasonable doubt, and the opportunity permits, the better method would be to verify the visibility by visiting the points concerned.

One accustomed to reading a map seldom finds it necessary to construct a profile of the terrain in order to determine the question of visibility. With combat troops in active operations, the lack of time, paraphernalia, and the errors that naturally creep in, due to the uncertainty of the height of the ground features and the possibility of slight errors in the map renders such a method of procedure almost impracticable. However, if one is accustomed to reading a contoured map, he can form a very accurate idea of the visibility of the terrain concerned by a hasty inspection of the map, bearing in mind the three common features of slopes, viz.: whether the particular slope concerned is uniform, concave or convex, or some combination of these features.

If the slope is uniform the contours will be equally spaced from top to bottom and all points on the slope may be seen from either the top or the bottom.

If the slope is concave, in which the contours are nearer together at the top and farther apart at the bottom, the entire slope may be observed from either top or bottom.

If the slope is convex, in which the contours are farther apart at the top and closer together at the bottom, only a portion of the slope is visible from either the top or the bottom.

The principles outlined above constitute the key to visibility. By a close study of the map, bearing in mind these principles, a commander of troops in operations can arrive at some pretty general and practicable conclusions relative to his dispositions. Thereafter it is a matter of personal reconnaissance which is always vital in active operations in order to discover the many possibilities of the terrain which no map, however accurate it may be, can convey.

However, if time is available, the necessary paraphernalia at hand, and a greater refinement of work is essential, the more complicated problems in visibility may be solved by what is commonly known as the *Profile Method.* The intersection of any surface by a vertical plane constitutes a profile of that surface. In other words, the profile of a slope is the intersection of that slope from top to bottom by a vertical plane.

For example, you wish to construct a profile of the line *ABC* (Figure 10). Place the lower edge of a piece of cross-section paper along the line *ABC*. Pick out the lowest contour lines along *ABC*. Naturally they are along the two streams, and both have an elevation of 500 feet. Mark dots on the lower edge of the paper indicating these lowest contours. Guided by the parallel and perpendicular lines of the cross-section paper, dot in the elevations of the remaining contours, allowing one horizontal space for each contour interval. Connect these dots by smooth curved lines, and you have the irregular line shown in Fig. 12. This is the profile of the line *ABC*. Then, by drawing lines of sight from the observing point tangent to the points of obstruction, the visible portions of the line *ABC* are determined.

Visibility problems may be divided into three classes:

1. To determine whether or not one point is visible from another.

2. To determine how much of the ground line connecting the two points is visible from either point.

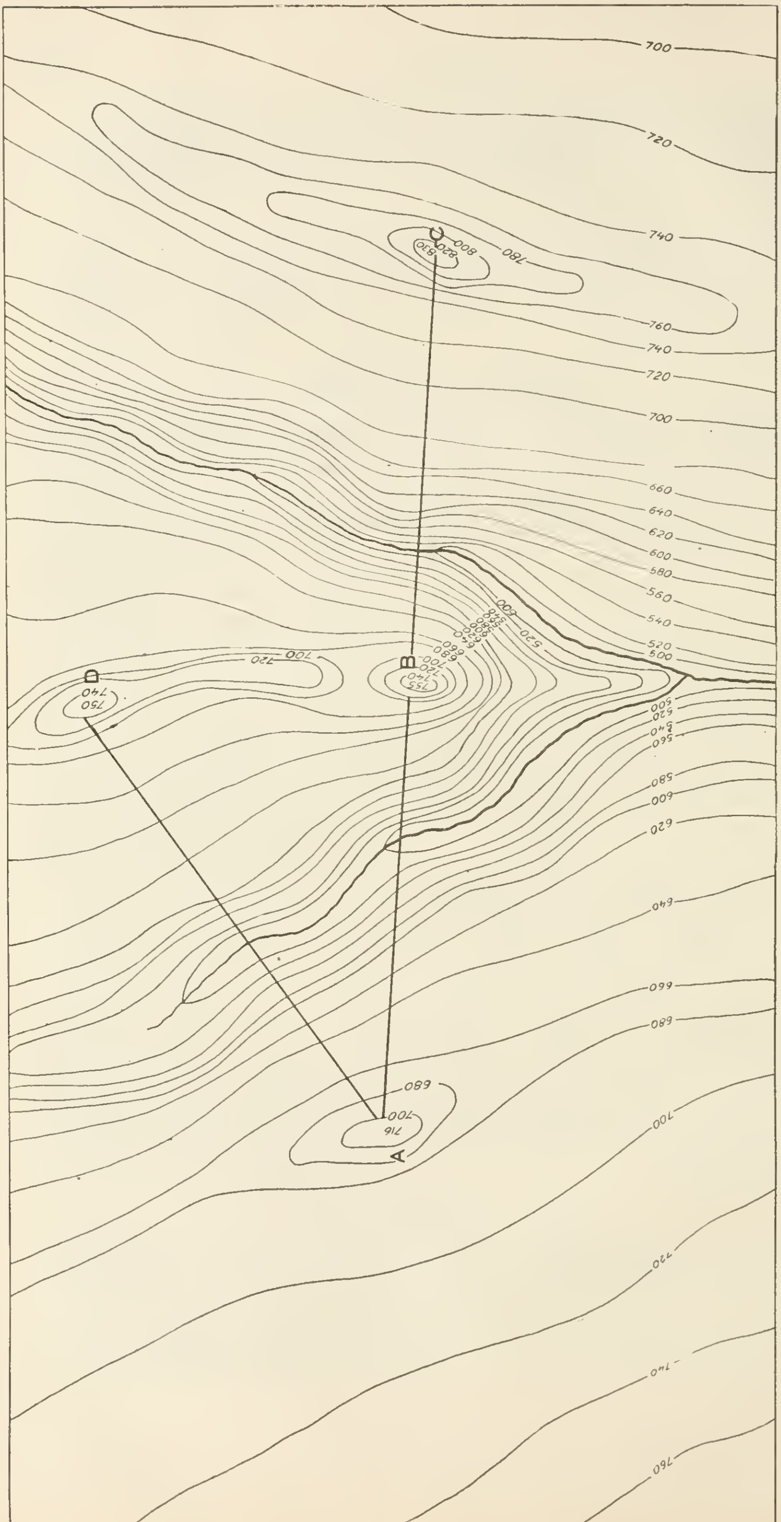
3. To determine how much of a certain area is visible from a given point.

VISIBILITY OF A POINT

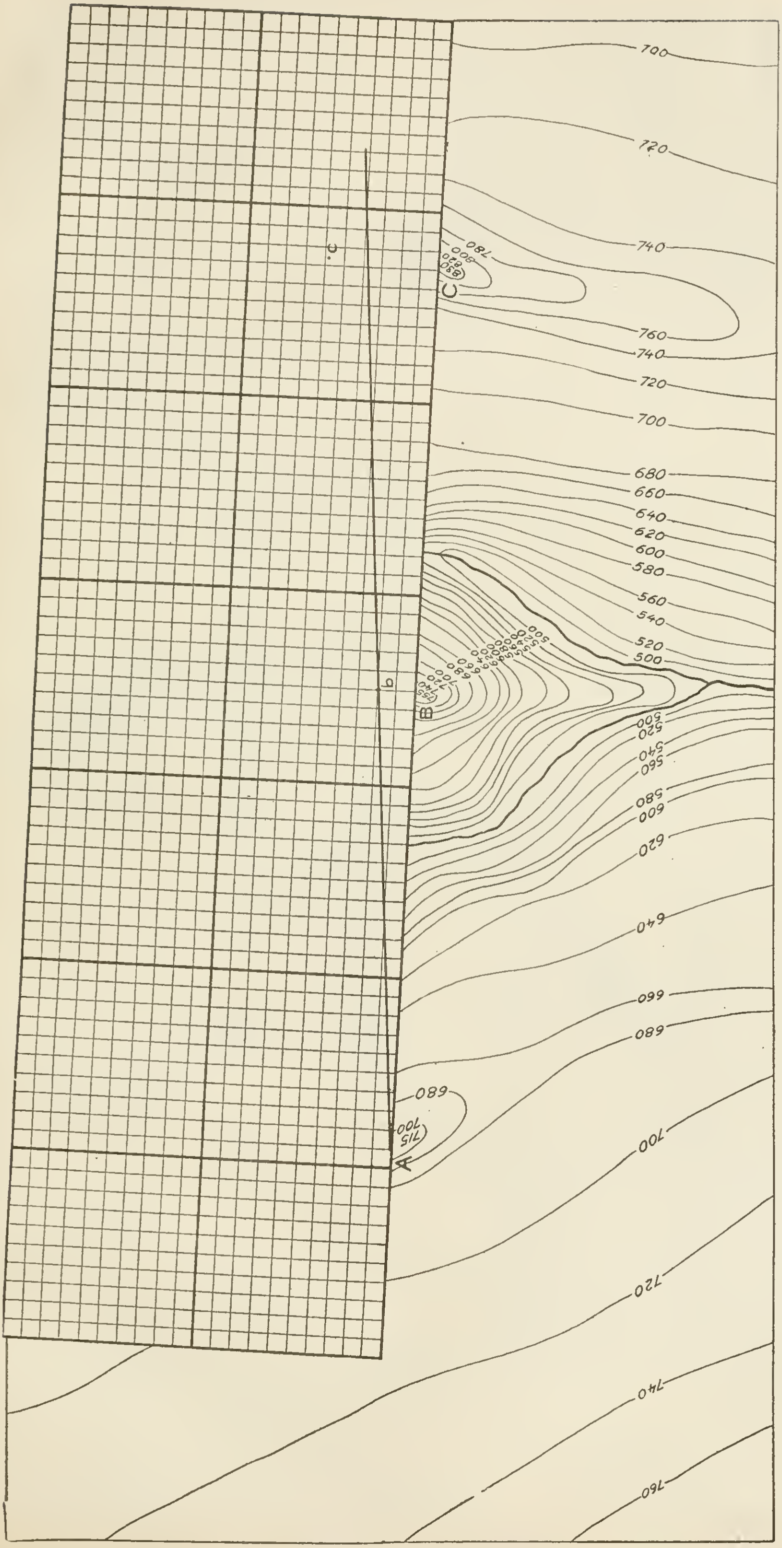
See Fig. 10. Let *A* be the observing point, *B* the point of probable obstruction. To determine whether the point *C* is visible from *A*. (Note that the contour interval is 20′.) As shown in Fig. 11, place the lower edge of the cross-section paper on the line *ABC*. Observing the points, *A, B,* and *C,* we find that *A* is the lowest point, *B* is 40 feet higher, and *C* is 115 feet higher than *A*. Let the space between the parallel lines on the cross-section paper represent one contour interval, so *B* will be two spaces higher than *A,* and *C* will be 5¾ spaces higher than *A*. As *A* is the lowest of the three points, its profile position will be at the lower edge of the cross-section paper, or is identical with its map position. The profile position of *B* is *b,* two spaces directly over *B;* the profile location of *C* is *c*, 5¾ spaces directly over *C*. Draw the line of sight from *a* tangent to *b*. It is found to pass beneath *c,* consequently *C* is visible from *A*. The visibility of any point may be determined in a similar manner. If there are several points of probable obstruction, locate the profile positions of each point, and, from the point of observation, draw tangents to each profile location and, if these lines fall below the profile location of the point in question, that point is visible.

VISIBILITY OF A LINE

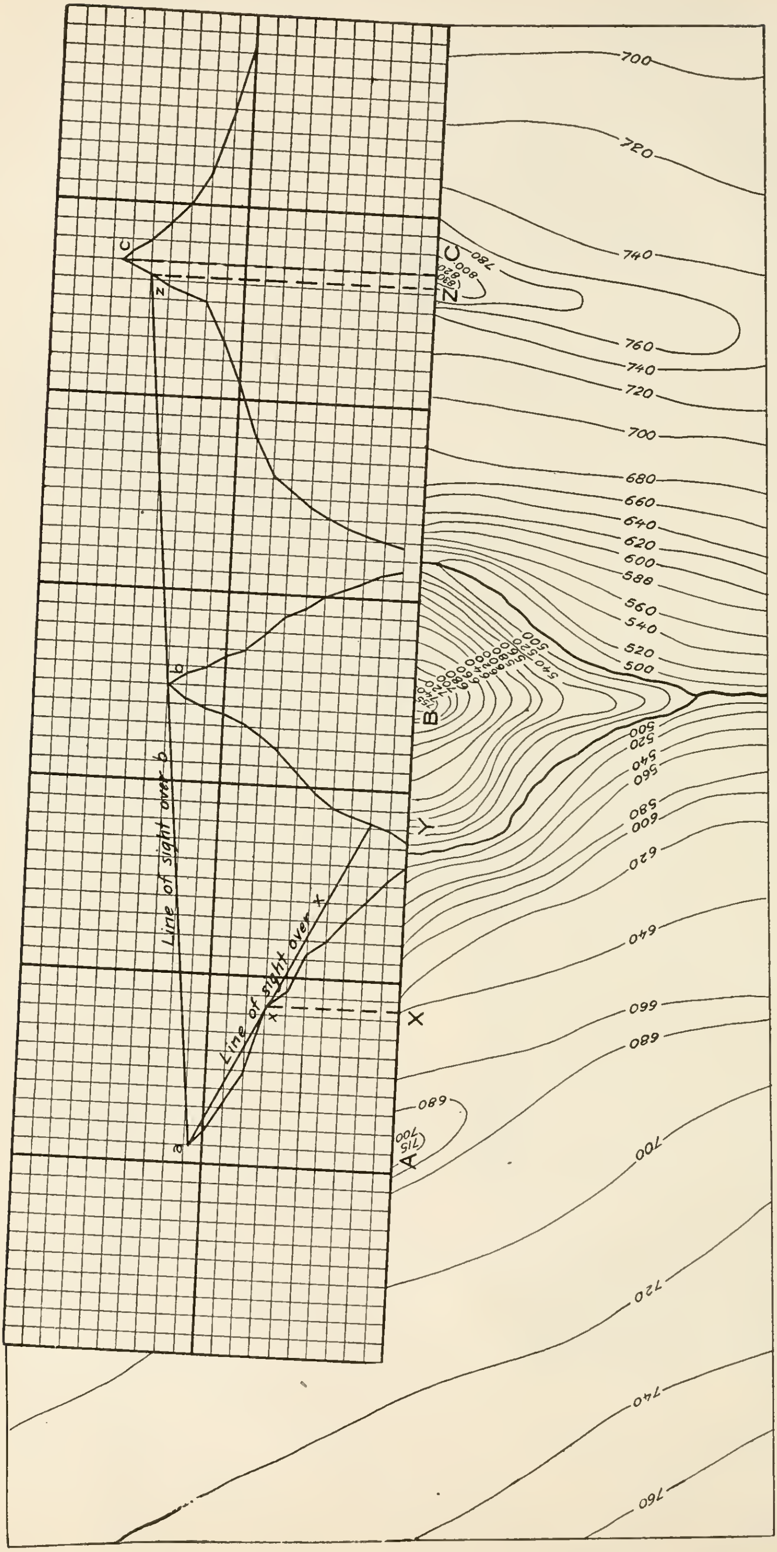
Construct the profile of the line as previously explained. From *a,* Fig. 12, draw lines tangent to the points of obstruction, *x* and *b*. (These are the lines of sight.) From the extremities of the visible portions of the profile, drop



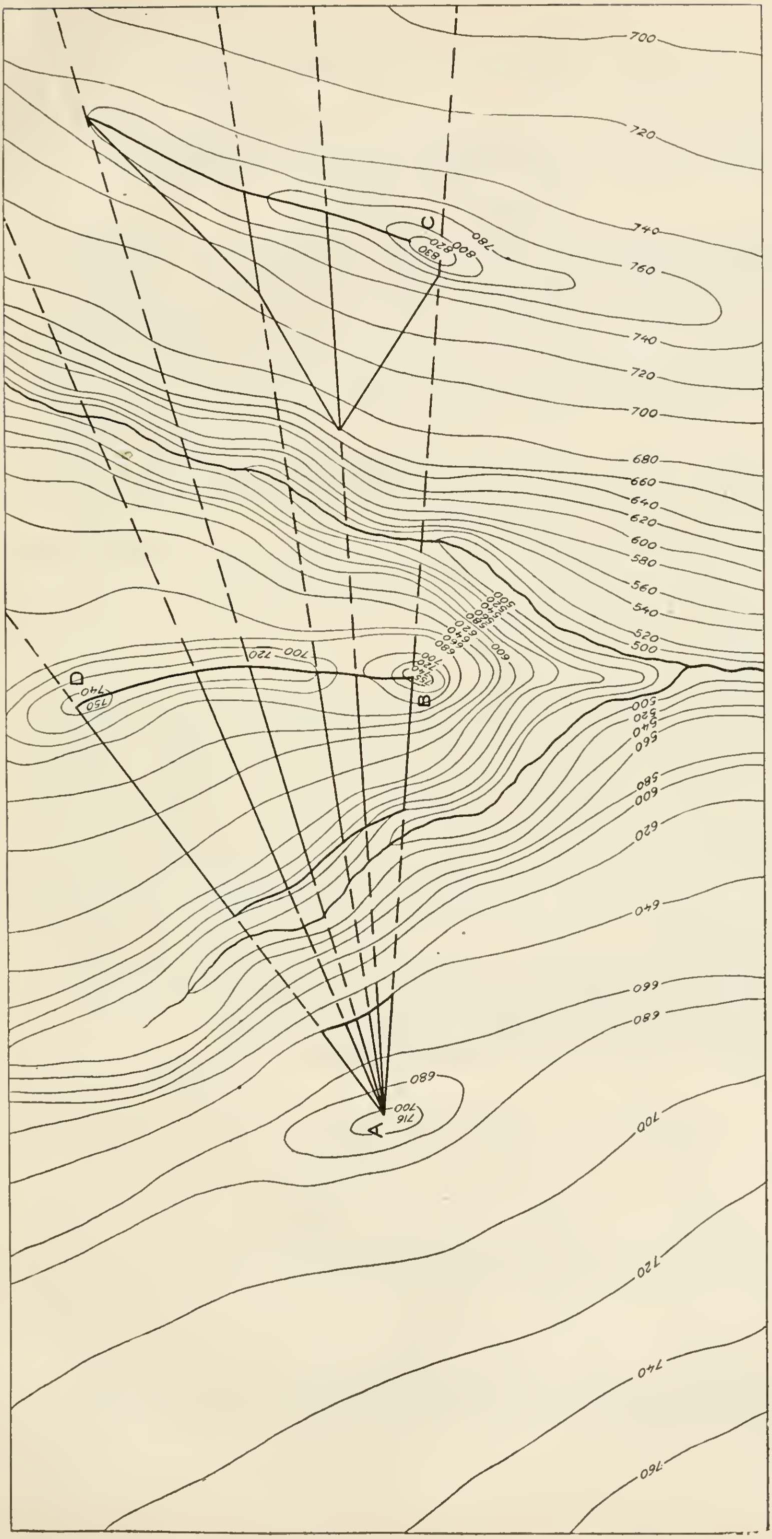
Scale, $\frac{1}{20000}$
V. I. 20′
Fig. 10



Scale, $\frac{1}{20000}$
V. I. 20′
Fig. 11



Scale, $\frac{1}{20000}$
V. I. 20′
Fig. 12



Scale, $\frac{1}{20000}$
V. I. 20′
Fig. 13

perpendiculars to the line *ABC*, and we find, of the line *ABC*, that *AX*, *YB*, and *ZC* are visible portions.

VISIBILITY OF AREAS

From the point of observation, draw several radiating lines through the critical points of the area in question. Find the visible portions of these lines by method suggested above, and connect their extremities, and you have approximately the visible area. (See Fig. 13.)

If the student is provided with a well-contoured map, some cross-section paper, and a pencil, he should be able in an hour's time, by the careful study of this lesson, to master the subject of visibility.

Each student should be furnished a well-contoured map and required to solve the following problems:

1. Find a uniform slope.
2. Find a concave slope.
3. Find a convex slope.
4. The instructor will select some point of observation and require the students to determine the visibility of several other points by inspection.
5. To determine the visibility of some point by the profile method.
6. To determine the visibility of a straight line by the profile method, the point of observation being located on the same line.
7. To determine the visibility of some crooked road, the point of observation being located off the road.
8. To determine the visible portion of a given area.

Lesson VI

Slopes as Applied to Military Operations

It is essential in military operations to study the contours of maps with a view of determining the practicability of troop and transport movements. In this connection there are a few standard abbreviations which are here explained:

V. I. (Vertical Interval), the vertical interval between contours, as, for example, 20 feet, 10 feet, etc.

M. D. (Map Distance). This refers to the horizontal distance on the map between two consecutive contours.

H. E. (Horizontal Equivalent). This refers to the horizontal distance on the ground between two consecutive contours.

The War Department has prescribed what is called the Normal System of scales and vertical intervals for military maps. The Normal System has reference to a fixed relation between the scale of a map and the vertical interval between contours, so that as one is increased the other is proportionately decreased. By this system the map distance is always the same for the same angle of slope whatever the scale of the map may be.

The new Normal System of scales and vertical intervals recently authorized by the War Department are as follows:

Road Sketches and Training Maps, scale, 1/20,000; V. I., 20 feet.

Position Sketches, scale, 1/10,000; V. I., 10 feet.

Fortification Sketches, scale 1/5,000; V. I., 5 feet.

The old Normal System was:

Road Sketches, scale, 3″ equals 1 mile; V. I., 20 feet.

Position Sketches, scale, 6″ equals 1 mile; V. I., 10 feet.

Fortification Sketches, scale, 12″ equals 1 mile; V. I., 5 feet.

As we have many of the maps made under the old Normal System, we will find in the future that the maps

in use may be made on any of the scales noted above. However, the map distance for any angle of slope for any of the scales noted above may be found by applying the following equation:

$$\text{M. D.} = \frac{688 \times \text{R.F.} \times \text{V.I.}}{\text{Angle of Slope.}}$$

In which 688 equals the horizontal distance in inches on a one degree slope necessary to give a rise of one foot.

R.F. equals the Representative Fraction, as, for example, 1/20,000, or, in event the scale is 3″ equals 1 mile, the R.F. would be 1/21,120. The V.I. is expressed in terms of feet, its function in the equation being relative only.

By applying this equation, we find that the M.D. for one degree of slope for any map made in accordance with the new Normal System is .688 inch, or, for convenience in measurements, we will call it .69 inch.

Making the proper substitutions, the solution is as follows:

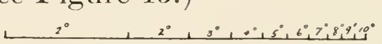
$$\frac{688 \times 1/20{,}000 \times 20}{1 \text{ degree}} = .688 \text{ inch, or } .69 \text{ inch.}$$

Similarly, by applying the same equation, we find that the M.D. for 1 degree of slope for any map made in accordance with the old Normal System is .651 +, or, for convenience in measurements, we will call it .65 inch.

Making the proper substitutions, the solution is as follows:

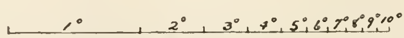
$$\frac{688 \times 1/21{,}120 \times 20}{1 \text{ degree slope}} = .651 +, \text{ or } .65 \text{ inch.}$$

Dividing .69 inch by 1, 2, 3, etc., we have the M.D.'s for 1, 2, 3, etc., degrees for any scale under the New Normal System. (See Figure 15.)



Scale of M.D's. Old Normal System

Fig. 14



Scale of M.D's. New Normal System

Fig. 15

Similarly, by dividing .65 inch by 1, 2, 3, etc., we have the M.D.'s for 1, 2, 3, etc., degrees for any scale under the Old Normal System. (See Figure 14.)

By the proper application of these scales, we can readily determine the degree of slope between contours, and, by means of the table given below, decide upon the practicability of various slopes for military operations.

Degrees of slope	Operations
1	Maximum for railroads.
3	Maximum for first-class roads.
5	Practicable for all arms. Somewhat difficult for cavalry to charge descending.
6	Maximum for cavalry to charge in mass ascending. Infantry in close order descends with some difficulty.
7	Cavalry can descend at a trot.
8	Not practicable for heavily loaded vehicles.
9½	Field artillery can no longer maneuver.
14 to 15	Maximum up to which all arms can move.
18½	Light vehicles can ascend.
26	Foot troops can ascend or descend aided by hands.

Slopes may be expressed in several ways, such as, degrees, percentages, gradients, etc.

If expressed in degrees, it means the angle between the horizontal and the line of slope.

If expressed in a percentage, as, for example, 5 percent, it means that in a horizontal distance of 100 units there is a rise of 5 of the same units.

If expressed in gradients, it is indicated as a fraction in which the numerator represents the difference in elevation, and the denominator the horizontal distance between the two points.

One degree of slope is approximately equivalent to 1.7 percent slope or a gradient of 1/60.

Students should be required to apply the equation for M.D., and to construct a scale of M.D.'s for both the Old and New Normal Systems.

As a matter of fact, one accustomed to reading a map will soon learn to estimate the degree of slope up to 10 degrees very accurately by inspecting the map, and the difference between the Old and New Normal Systems is so slight as to be almost negligible in map reading, although, in the construction of reading scales of M.D.'s, the equation should be applied in each case.

Lesson VII

Coordinates

In all maneuvers, battle orders and map problems it is essential to locate points, lines and areas briefly and accurately. This is done by means of coordinates, or, in other words, by the intersection of well-defined horizontal and perpendicular lines.

The system of coordinates employed at the General Service Schools, and generally adopted since the war, consists of a series of horizontal and perpendicular lines forming squares with lineal dimensions of 1,000 yards. (See Figure 16.) In order to avoid negative readings, the origin of these horizontal and perpendicular lines must be arbitrarily fixed at some point to the South and West of the area to be considered. However, this point is of no particular importance to the student so long as he understands how to read the coordinates.

The horizontal coordinates are read from West to East (left to right), and the vertical coordinates are read from South to North (bottom to top). In other words, the system consists in locating a point in terms of so many thousands of yards east, and so many thousands of yards north of some initial point. For all practical purposes a location within 100 yards (tenth of a thousand yards) is sufficiently accurate.

The coordinate read from left to right, assuming that the top of the map is north, is called the *X* coordinate, and the coordinate read from bottom toward the top is called the *Y* coordinate. In writing coordinates, place the *X* coordinate first, separating it from the *Y* coordinate by a dash. If several coordinates are given, as would be necessary in locating a certain line on the map, the coordinates locating each point of the line are separated by commas.

Suppose we wish to locate the R. Schwartz house. (See Map.) We find that it is 354.4 thousand yards east of the initial point, and 746.8 thousand yards north of the initial point. Placing the *X* coordinate first and separating it from the *Y* coordinate by a dash, we have 354.4-

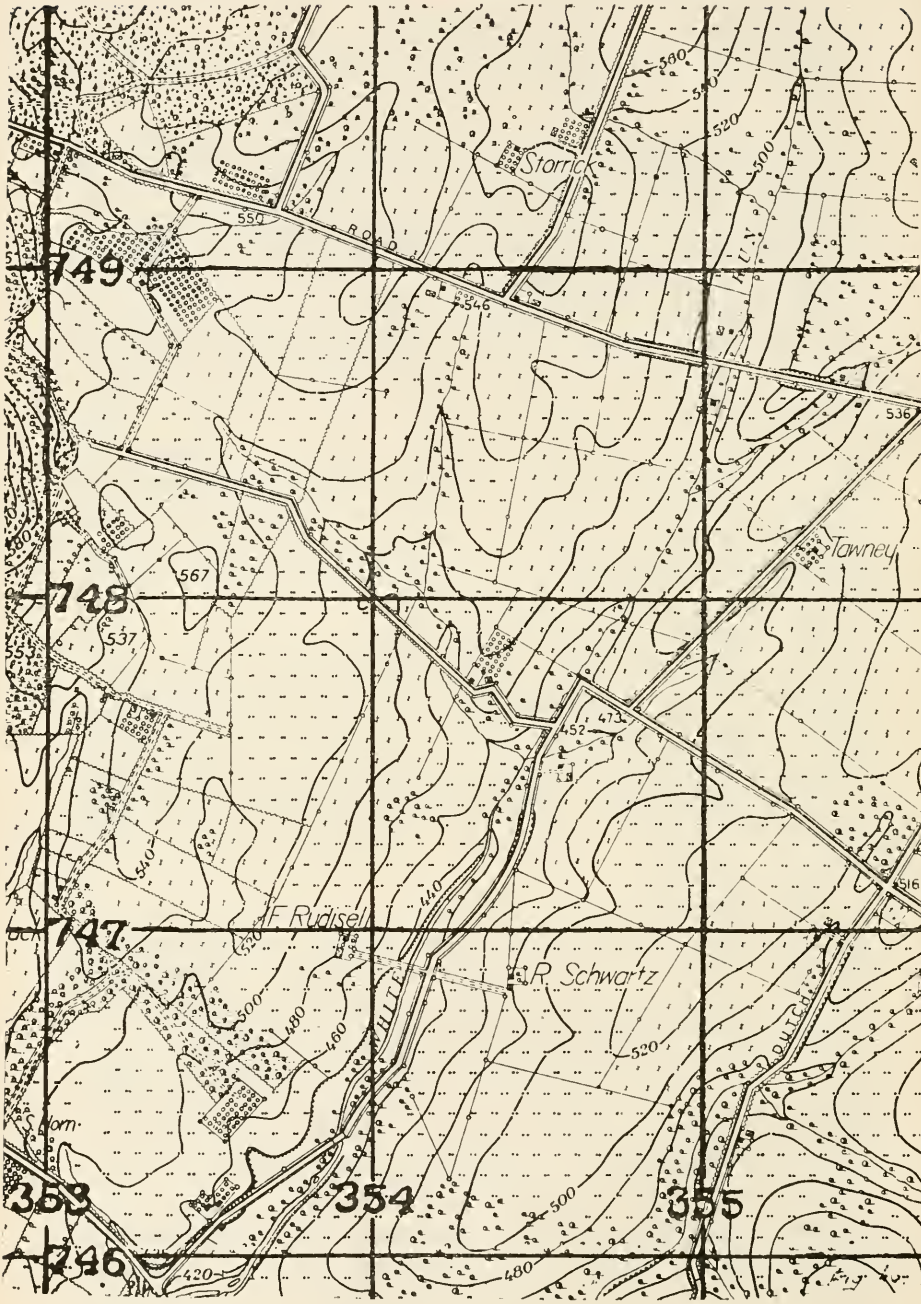

749
748
747
746
353
354
355
Storrick
ROAD
550
546
560
540
520
500
536
Tawney
567
537
473
452
540
516
F. Rudisel
R. Schwartz
440
500
480
460
520
500
480
420

Fig. 16

746.8 as the coordinates of the house which locates it definitely.

Now suppose that we wish to locate the line: R. Schwartz house—point 473- point 536, the coordinates would be as follows: 354.4-746.8, 354.7-747.6, 355.6-748.6, separating each set of coordinates by a comma.

Usually one is able to estimate between the thousand-yard lines with sufficient accuracy to determine tenths of thousands. If greater refinement is required in locating a point, suitable scales, such as a boxwood scale, may be employed to read to a hundredth of a thousand (to ten yards), or a thousandth of a thousand (to one yard), but this refinement is seldom necessary. The coordinates for R. Schwartz house might then read: 354.46-746.84, which would locate the house to within ten yards of its center, or 354.466-746.847, which would locate to within one yard of the center of the house if such a refinement were possible.

In case of a small map, such as given in this lesson, it is not necessary to write out all of the figures to the left of the decimal point. In other words the coordinates, 4.4-6.8 would sufficiently identify the Schwartz house, or if the map were larger, two figures to the left of the decimal point might be necessary to identify a location.

It is very important that those using military maps be able to read coordinates rapidly, and a few simple exercises are given at the close of the lesson. In addition thereto the instructor, or in the absence of an instructor, the student should improvise and solve many simple problems in coordinates until proficiency is attained.

Exercises

1. Locate by means of coordinates the following points on the map: The Towney house, the F. Rudisell house, the Storrick house, the corner at 546, the corner at 550.

2. Suppose that a line corresponding to the road, 516-473-452 thence northwest to the woods were occupied by our troops. Locate this line by means of coordinates.

3. Locate by means of coordinates the road, 536-546-550 thence west to the west margin of the map.

Lesson VIII

Reading Scales, Legends, Etc.

The American soldier thinks in terms of yards. Consequently, in order that distances may be read correctly, every map should have a reading scale of yards, usually shown at the bottom of the map.

Let us assume that the scale of your map is 1/20,000. Then 1 inch on your may equals 20,000 inches or 555.55 yards on the ground.

Suppose that you desire a scale to read to 2,000 yards.

$$2{,}000 \div 555.55 = 3.6 \text{ inches.}$$

With a boxwood scale lay off a line 3.6 inches long, and divide it into convenient divisions for reading distances.

To divide a line 3.6 inches long into equal parts, proceed as follows:

Let the line *AB*, Figure 17, be 3.6 inches long, and the line *AC* be of convenient length to divide into, say, 20 equal parts. Draw a straight line connecting B and C, and then draw lines parallel to *BC* as needed to make suitable divisions of the line *AB*. *AB* is your reading scale of yards.

Again, let us assume that the scale of your map is 3″ equals one mile, then

$$3'' \text{ on the map} = 63{,}360 \text{ inches on the ground.}$$
$$1'' \text{ on the map} = 21{,}120 \text{ inches on the ground.}$$
$$1'' \text{ on the map} = 586.66 \text{ yards on the ground.}$$

Assume, as before, that you desire a reading scale that reads to 2,000 yards.

$$2{,}000 \div 586.66 = 3.4 \text{ inches.}$$

Construct the scale as described in the previous problem.

Every map should contain the following data, usually at the bottom of the sheet:

1. The area included by the map, as, GETTYSBURG-ANTIETAM MAP, Emmitsburg Sheet.
2. The authority for making the map, as, by Captain

William Jones, 37th Infantry, under the direction of the Commanding Officer, 37th Infantry.

3. The date.
4. The scale of the map, as, scale, 1/20,000.
5. A suitable reading scale, usually expressed in yards.
6. A scale of Map Distances.
7. The true and magnetic meridians should be indicated.
8. Instruments used in making the map.

Whenever you use a map study the data noted above very carefully. It is very significant, as, for example, a map made under the supervision of the Chief of Engineers of the Army or under the supervision of the Chief of the Geological Survey would be much more reliable than one made by Jim Hickey, Surveyor of Newago County.

The date—if the map is ten years old, it is very probably obsolete in many respects.

The scale of the map—is it suitable for your particular use?

The instruments used—was a general triangulation scheme laid out with a transit and level, or was the map roughly sketched in its entirety with no reference to bench marks, etc.?

If the legend is complete, you will be able to form a very good idea of the value of the map.

The following problems and solutions pertain to reading scales:

1. A French map, made to read in meters, has on it R.F. equals 1/100,000. What would be its proper R.F. for use in this country where we usually read maps in yards?

SOLUTION:

R.F. = 1/100,000 means that one unit (of any unit of measure) on the map represents 100,000 like units on the ground. It makes no difference whether these units be inches, centimeters, or what. Therefore the R.F. does not change, no matter what the unit of measure considered.

Ans. R.F. = 1/100,000.

2. You have a map which has at its bottom the remark,

R.F. = 1/25,000. Construct a reading scale to read yards. Show 2,000 yards.

SOLUTION:

R.F. = 1/25,000 means that one inch on the map represents 25,000 inches on the ground, hence

1 inch (map) = 25,000 inches (ground) = 694.4 yds. (ground).

Since 1 inch on the map represents 694.4 yds. on the ground, and we want to represent 2,000 yds., we have:

694.4 : 2,000 :: 1 inch : (x) inches.

x = 2.88 inches.

Draw a line 2.88 inches long and subdivide it as explained in Figure 17.

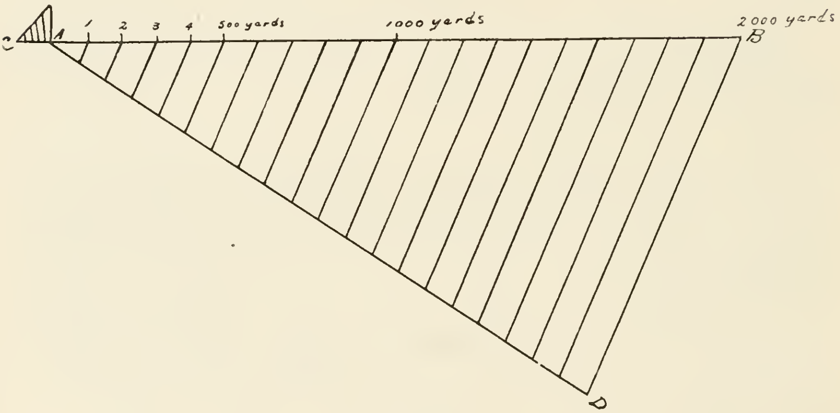


Fig. 17.

3. A map at its bottom has a remark reading R.F. = 1/10560 and a graphical scale. You have not the original but a photographic copy that is only half the dimensions of the original. Both map and scale were reduced in the photograph, and the photograph shows the R.F. as it read on the original.

(*a*) Can you use the graphical scale as shown on the photograph for reading the photographic map? If not, construct a proper scale for it.

(*b*) Is the R.F. shown on the photographic map correct? If not, what should it be?

SOLUTION:

(*a*) Yes. Both map and scale were reduced, and they were reduced in the same proportion.

(*b*) No. A distance on the ground that was represented by one inch on the original will be represented by ½ inch on the photographic copy. On the original, one inch on the map represented 10,560 inches on the ground, or one inch on the copy represents 21,120 inches on the ground, hence

Ans. R.F. = 1/21,120.

4. You have an old German map made to read in Prussian decimal feet. A Prussian decimal foot equals 15 inches. The map shows that the R.F. equals 1/8000.

(*a*) What is its R.F. for our use?

(*b*) Construct a reading scale to read English feet. Show 2500 feet.

SOLUTION:

(*a*) Ans. R.F. = 1/8000. For reasons, see answer to problem No. 1.

(*b*) R.F. = 1/8000. One inch on the map represents 8000 inches on the ground. 8000 inches equals 666.66 feet. We desire to show 2500 feet, hence:

$$666.66 : 2500 :: 1 \text{ inch} : x \text{ inches.}$$
$$x = 3.75 \text{ inches.}$$

Draw a line 3.75 inches long and divide it as described in Problem No. 2.

5. You have found a map with no scale or R.F. on it. You can recognize on both map and ground two points that are found to be 2500 feet apart on the ground and their locations on the map are three inches apart.

(*a*) What is the R.F. of the map?

(*b*) Make a reading scale to read to yards. Show 1500 yards.

(*c*) Make a reading scale to show miles. Show one mile divided into quarters and eighths.

SOLUTION:

(*a*) Three inches on the map represents 2500 feet on the ground. 2500 feet × 12 = 30,000 inches on the ground. If three inches on the map represents 30,000

inches on the ground, one inch on the map will represent 10,000 inches on the ground. Hence: R.F. = 1/10000.

(*b*) One inch on the map represents 10,000 inches or 277.7 yards on the ground, but we wish to represent 1500 yards.

277.7 : 1500 :: 1 inch : x inches.

x = 5.41 inches.

Lay off a line 5.41 inches long and divide so as to show 1500 yards in the same manner as explained in Problem No. 2.

(*c*) As shown in (*b*), one inch on the map equals 277.7 yards on the ground. One mile equals 1760 yards. Hence:

277.7 : 1760 :: 1 inch : x inches.

x = 6.33 inches.

Draw a line 6.33 inches long and divide into eight parts, each part representing one-eighth of a mile.

6. You have a map which shows that its R.F. = 1/25000. Construct a reading scale to read yards. Show 4000 yards.

SOLUTION:

R.F. = 1/25000 means that one inch on the map equals 25,000 inches on the ground = 694.4 yards on the ground. Hence:

694.4 : 4000 :: 1 inch : x inches.

x = 5.76 inches.

Lay off a line 5.76 inches long and construct the scale as described in problem No. 1 of the text.

PART TWO

Military Sketching

While the officer and noncommissioned may be able to perform their duties successfully with little or no knowledge of military sketching, yet, from another point of view, a working knowledge of military sketching has two advantages which no military man can afford to miss, viz.: It fixes forever in the mind of the student the salient principles of map reading, and it affords the best opportunity available to become familiar with terrain features, and, in addition thereto, it is frequently absolutely necessary that the officer or noncommissioned officer submit a sketch in order to elucidate a report, or for many other purposes.

The B-H Relief Map, designed by Colonel A. W. Bjornstad, is now installed in many educational institutions, and used by nearly every Regular and National Guard organization. Through the courtesy of Colonel Bjornstad, Figures 32 to 35 inclusive were taken directly from the B-H Relief Map. As all of the explanations pertaining to the various classes of sketches employed in this text pertain to certain areas embodied in the B-H Relief Map, the use of this text in connection with the B-H Map would be most practicable.

Lesson IX

Construction of Working Scales

Before taking up the subject of sketching, the student must determine the length of his pace or stride.

An accurately measured course of at least one thousand yards should be selected. A thousand yards on the target range will answer the purpose, or, if a target range is not available, a course may be measured, preferably on turf rather than on a macadamized road or sidewalk. While pacing, one should take an easy, natural, and uniform gait. This is important as there is always a tendency on the part of the beginner to consider pacing and his natural gait as entirely distinct, which usually results in his first scale of paces or strides being too long. This may be obviated by pacing a sufficiently long course several times (four times is suggested), first impressing upon the student's mind the necessity of taking a natural and uniform gait.

Let us assume that each student has paced the course four times, and that his four results of pacing a course 1,000 yards long are:

1118 paces.
1109 "
1120 "
1117 "

Total 4464 paces.

$4464 \div 4 = 1116$ paces (average number of his paces for 1,000 yards).

To determine the length of his pace in inches:

1,000 yards = 36,000 inches.

$36{,}000 \div 1116 = 32.2$ inches, the length of his pace.

Before computing the length of his pace, each student should present his results of pacing to the instructor for verification, and, if any wide discrepancies exist, the student should be required to pace the course again.

To avoid error in pacing, the student should keep a record of the number of paces by making a mark for each 100 paces. A pace tally may be used if available. A hand instrument known as a "Tallying Register" may be used in recording the number of strides, if a scale of strides is desired.

To construct a working scale of paces whatever the scale of your map is to be, the method of procedure is as follows:

1. Find the length of your pace.
2. Find how many of your paces will be represented by one inch on the map.
3. Find the length in inches of your working scale.
4. Construct the scale.

Let us assume that the student has paced a course of 1000 yards, and found that the length of his pace is 32.2 inches as given above. This completes the first step.

To find how many of his paces will be represented by one inch on the map, assuming that the scale of the map is to be 1/20000.

1 inch on the map = 20,000 on the ground.

20,000 ÷ 32.2 = 621 of your paces.

Now suppose that you desire a working scale that reads to 2,400 paces.

1 inch = 621 paces.

2,400 ÷ 621 = 3.86 inches, the length of the scale.

To construct the scale: Lay off the line *AB*, Fig. 18, 3.86 inches long, which represents 2,400 paces. Divide this line into 24 equal divisions representing 100 paces each. To the left of your scale, extend the line a distance equal to 100 paces, and subdivide this length into five equal parts, each representing 20 paces. Transfer these divisions to a suitable straight-edged ruler and your working scale is completed. Working scales for 1/10,000, 1/5,000, or for 3″=1 mile, 6″=1 mile, etc., may be constructed in a similar manner.

To divide the line *AB* (Fig. 18) into 24 equal parts, lay off any line *AC* which may be conveniently divided into 24 equal parts. Draw a straight line connecting *B*

and *C,* then draw lines parallel to *BC,* as shown in the figure. These lines will divide the line *AB* into 24 equal divisions of 100 paces each. Use the same method in dividing the extension scale to represent 20 paces each.

The ruler shown in Figure 19 is manufactured at the General Service Schools, and is very convenient for sketching purposes. It is made of heavy hardwood, which gives it sufficient weight to hold it to the paper. The

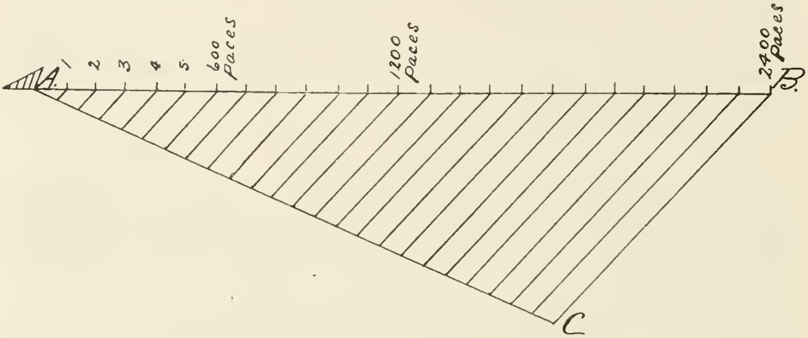


Fig. 18.

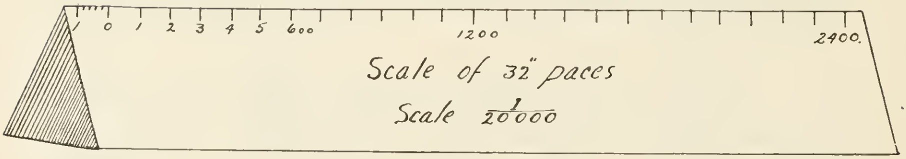


Fig. 19.

sharp edges make excellent sighting lines. If you will write to the Book Department, General Service Schools, informing them of the length of your pace or stride, they will furnish you with one of these rules at slight cost.

After determining the length of your pace or stride, your working scale may be transferred to a suitable ruler from the consolidated scales given at the close of this lesson. This is found to be much more practicable, especially for some noncommissioned officers. As a matter of fact the working scale is just as much of an instrument

in sketching as the compass, and should be provided whenever the opportunity permits.

PROBLEMS IN WORKING SCALES

1. What is the R. F. of a map made by pacing when 1 inch on the map represents 352 strides of 60 inches each?

SOLUTION:

1 inch on the map = 352 strides on the ground.

Each stride = 60 inches.

Hence: 1 inch on the map = $352 \times 60 = 21{,}120$ inches on the ground. Since 1 inch on the map equals 21,120 inches on the ground, the scale of the map is 1/21,120.

2. Construct a working scale of trots for $6'' = 1$ mile for use with a horse that trots a mile in $5\frac{1}{2}$ minutes. Show 10 minutes of scale.

SOLUTION:

$6''$ on the map equals 1 mile on the ground equals $5\frac{1}{2}$ minutes for the horse. It takes the horse $5\frac{1}{2}$ minutes to cover the distance that will be represented by six inches on the map or scale. We desire to show 10 minutes on our scale. Hence:

$5\frac{1}{2} : 10 :: 6$ inches : x inches.

x = 10.9 inches.

Draw a line 10.9 inches long and divide it into 10 equal parts, each of which will represent one minute. Divide the left one of these divisions into six equal parts, each of which will represent 10 seconds.

3. Your horse walks 7 miles in one hour and 38 minutes. Construct a working scale of minutes for use in making a road sketch, scale 1/20,000. Show 20 minutes.

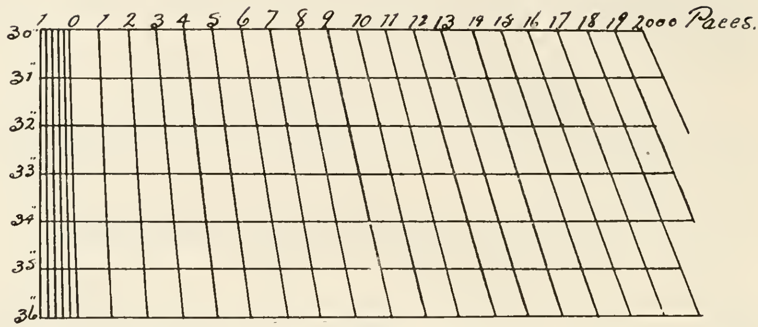
SOLUTION:

The horse walks 7 miles in one hour and 38 minutes, or 98 minutes. Since the horse walks 7 miles in 98 minutes, it will walk 1 mile, or 63,360 inches, in 14 minutes, or 4,525 inches in 1 minute, or 90,500 inches in 20 minutes.

1 inch on the map = 20,000 inches on the ground.

$90{,}500 \div 20{,}000 = 4.52$ inches on the map.

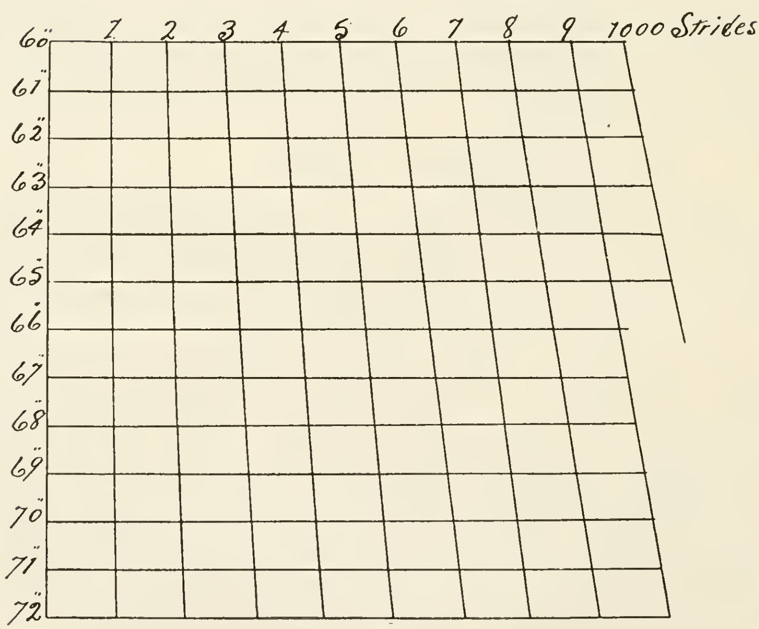
4.52 inches on the map equals 20 minutes for the horse to walk.



CONSOLIDATED SCALE OF PACES

Scale: $\frac{1}{20000}$

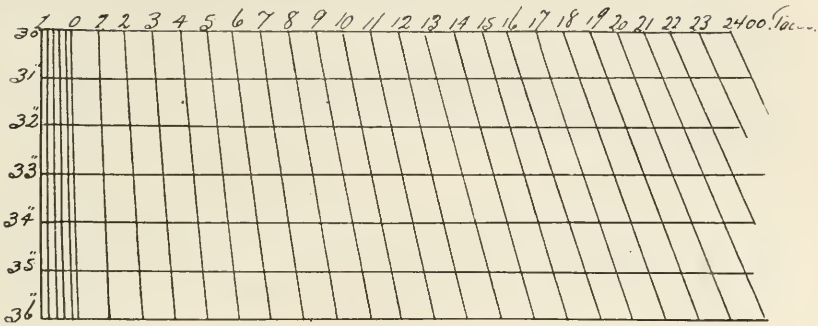
Fig. 20a.



CONSOLIDATED SCALE OF STRIDES

Scale: $\frac{1}{20000}$

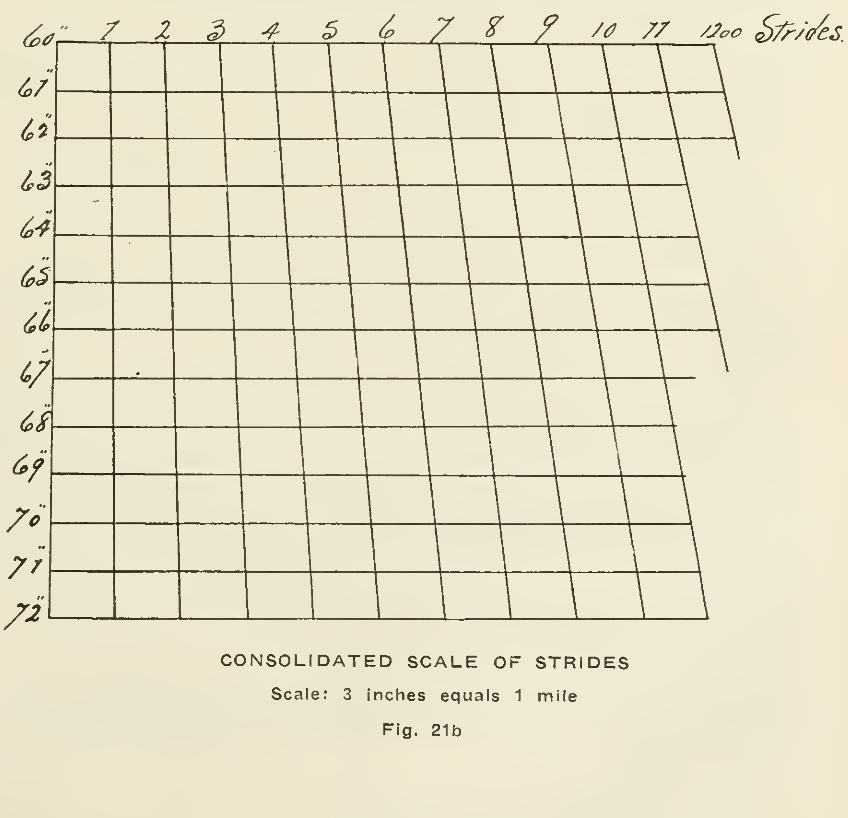
Fig. 20b.



CONSOLIDATED SCALE OF PACES

Scale: 3 inches equals 1 mile

Fig. 21a



CONSOLIDATED SCALE OF STRIDES

Scale: 3 inches equals 1 mile

Fig. 21b

Lay off a line 4.52 inches long, and divide it into 20 equal parts. Subdivide the left-hand division into six equal parts of 10 seconds each.

4. You take 880 strides in going a mile. Construct yourself a working scale for R. F. = 1/21,120 to show 1,000 yards.

SOLUTION:

R. F. equals 1/21,120 means 3 inches equals 1 mile. You take 880 strides in going 1 mile. Therefore, you will represent 880 of your strides by 3 inches on the scale.

That is, 3 inches on the map equals 1 mile on the ground equals 880 strides on the ground. You wish to represent 1,000 strides on your scale. Hence:

$$880 : 1{,}000 :: 3 : x$$

$$x = 3.41 \text{ inches.}$$

Lay off a line 3.41 inches long and construct the scale in accordance with previous instructions.

5. You take a 64-inch stride. Construct yourself a working scale for making a position sketch, scale 1/10,000. Show 1,000 strides.

SOLUTION:

Since the scale is 1/10,000, 1 inch on the map equals 10,000 inches on the ground.

$10{,}000 \div 64 = 156.25$ strides on the ground.

If the scale is to represent 1,000 strides, by dividing 1,000 by 156.25, we find that the scale must be 6.4 inches long.

Lay off a line 6.4 inches long, and, in accordance with previous instruction, divide it into 10 equal parts, each part representing 100 strides. Subdivide the left-hand division into five equal parts, each representing 20 strides.

6. A horse trots a mile in 6 minutes. Construct a working scale for R. F. equals 1/21,120. Show 15 minutes. Construct a reading scale to read yards to go with the map. Show 2,000 yards.

SOLUTION:

Six minutes by horse equals 1 mile ground equals 3 inches map. We want to show 15 minutes of scale.

Hence:

6 : 15 :: 3 inches : x inches.

x = 7½ inches.

Also for the second part of the problem:

R. F. = 1/21,120, which means that 3 inches equals 1 mile. One mile equals 1,760 yards. We want to show 2,000 yards. Hence:

1,760 : 2000 :: 3 inches : x inches.

x = 3.41 inches.

Construct both scales in accordance with previous instructions.

Lesson X

The Flat Sketch

Having completed the course outlined for map reading, we will now take up the subject of military sketching. In a way these two subjects go hand in hand, as one is taught the other is learned. If one thoroughly understands military sketching, he naturally will be able to read a military map, but, for convenience of instruction, the subjects have been divided.

Before taking up the subject of sketching each student should be equipped with a drawing board with an attachment for reading angles of slope, compass, a working scale as shown in Fig. 19, Faber's HB pencil or one of about the same degree of hardness, an eraser, and a pocket knife or pencil sharpener. A tripod in connection with the drawing board is of assistance to the beginner, although not absolutely necessary.

The Engineer drawing board with attached compass and tripod, although excellent, is very expensive, and would not be found practicable on that account with large classes such as would be the case at educational institutions. The improvised drawing board and tripod shown in Fig. 22 are suggested. They are easy of construction and will be found entirely practicable.

The Drawing Board

The drawing board should be of soft pine, so that thumb-tacks can be inserted easily. A board about 14″ by 14″ by 1″ is a very convenient size. This surface is sufficient for a position sketch of four square miles with an inch margin. The compass may be set into the middle of one side of the drawing board by cutting or boring into the board. The author will not attempt to recommend any particular compass. What is known as the watch compass is issued to organizations of the regular army at present. Some good round case compass that could

be set into a round hole in the board is recommended. In anticipating this course, the instructor should write to some dealer for samples, select the most practicable compass as to cost and efficiency, and then endeavor to secure a discount by ordering for the entire class.

The Tripod

Select a piece of "Two by four" 5 inches long (see Fig. 22-b), and three sticks 4′ by 1″ by ½″, the latter of some tough material which will not be easily broken. About ¾″ from the end of these sticks bore holes ½″ in diameter. At the middle of one end of the block saw out a slit ¾″ wide and extending an inch and a half into the block. By means of wire nails driven as shown in Fig. 22-c, attach the three legs to the block, one leg in the slit and the remaining two legs at the other end of the block. Then drive a wire nail into the center of the bottom of the block; the nail being of sufficient length so that it will protrude ¾″ out of the block. (See Fig. 22-c.) When all of this has been completed, you will have a tripod something like Fig. 22-d. Now bore a hole ¾″ deep into the center of the bottom of your drawing board, the diameter of this hole being just sufficient to accommodate the wire nail protruding from the top of the tripod. Now attach the drawing board to the tripod by means of the nail and hole just described, and you will have a drawing board and tripod complete, by means of which the drawing board may be quickly oriented and leveled; also the board may be easily detached from the tripod when it becomes necessary to read angles of slope from the attachment on the board. As stated heretofore, the tripod is of assistance to the beginner, although not really necessary, but is usually discarded by the experienced sketcher as being too much bother in hasty military sketching.

The student being equipped as noted above, is now ready to begin sketching.

Fig. 23 represents the road *ABCD* to be sketched.

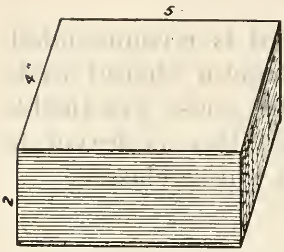


Fig. b

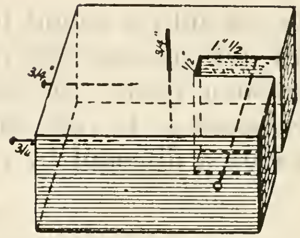


Fig. c.

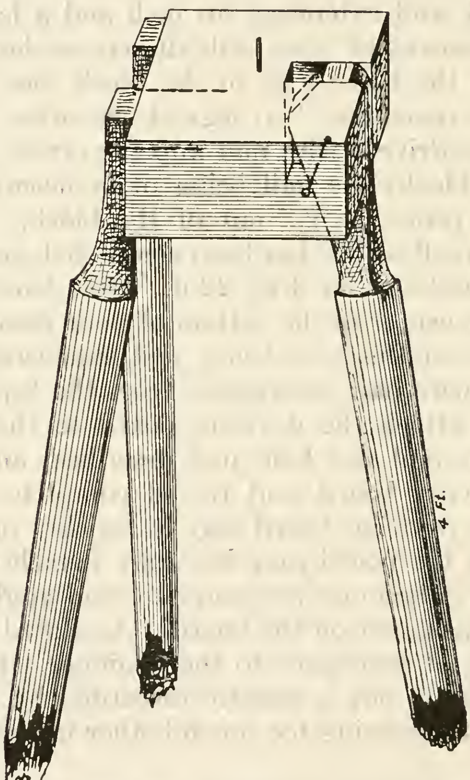


Fig. d

Fig. 22

On your paper draw a straight line representing the magnetic north. Mark one end of this line N.

In sketching, always hold your drawing board in such a position that the north end of the compass needle and the arrow end of the magnetic north indicated on the

Fig. 23

paper are pointing in the same direction. In the future we will refer to this operation as "Orienting the board."

Go to the point *A* on the road. (See Fig. 24.) Orient

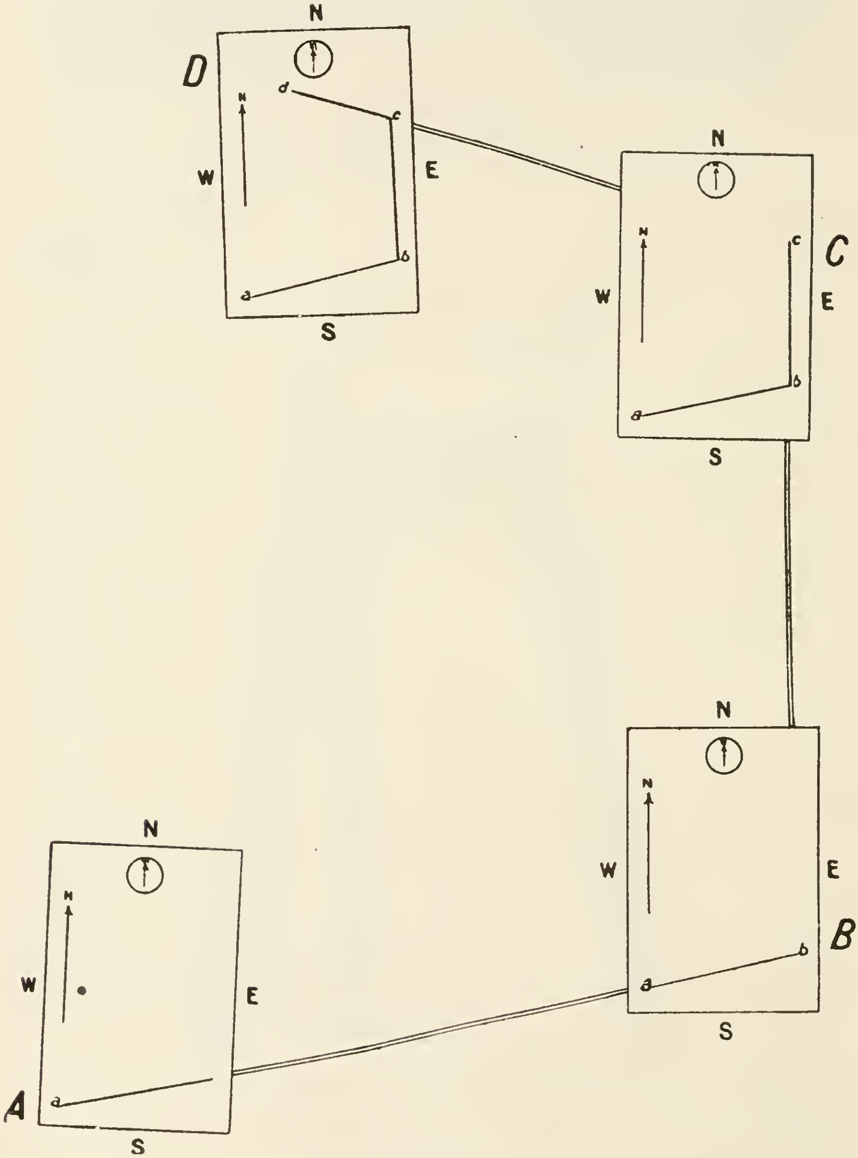


Fig. 24

the board. From any convenient point a on the board, draw a straight line in the direction Ab. Next, pace the distance from A to B, and, with your scale of paces, scale, $\frac{1}{20,000}$ or $3'' = 1$ mile as the case may be, lay off the line, ab, representing the distance AB. In locating the initial point a, one usually knows the general direction of the course to be sketched, and should select a point of beginning which will afford the greatest use of the paper. For example, if your course takes in an easterly direction, your point of beginning should be near the west margin of the paper.

Now orient the board at B, draw a straight line in the direction BC, pace BC, and lay off the line bc.

Orient the board at C, draw a line in the direction CD, pace CD, and lay off the line CD.

The instructor should require each student to plot a short course having several changes of direction. Results should be compared and errors pointed out. An accurate sketch of the route should be exhibited, and each student's sketch compared with it.

The instructor should then select some longer course in which the points of beginning and ending are the same, as, for example, the course $ABCDEFA$—Fig. 25. This will serve as an excellent check on the work. The methods employed will be the same as described above except that important points to the right and left of the course should be located by intersection, and locations along the course should be verified by resection.

To Locate a Point by Intersection

NOTE.—Contouring will not be attempted in this sketch, which is known as a "Flat Sketch." Vegetation may be indicated in writing, and hill tops indicated by a dot or star. (See Fig. 25.)

To locate a point by intersection—as, for example, the hill-top G, Fig. 25—orient the board at A (see Fig. 26 in connection with Fig. 25); mark the point a on the board to correspond to A on the ground. Sight in the

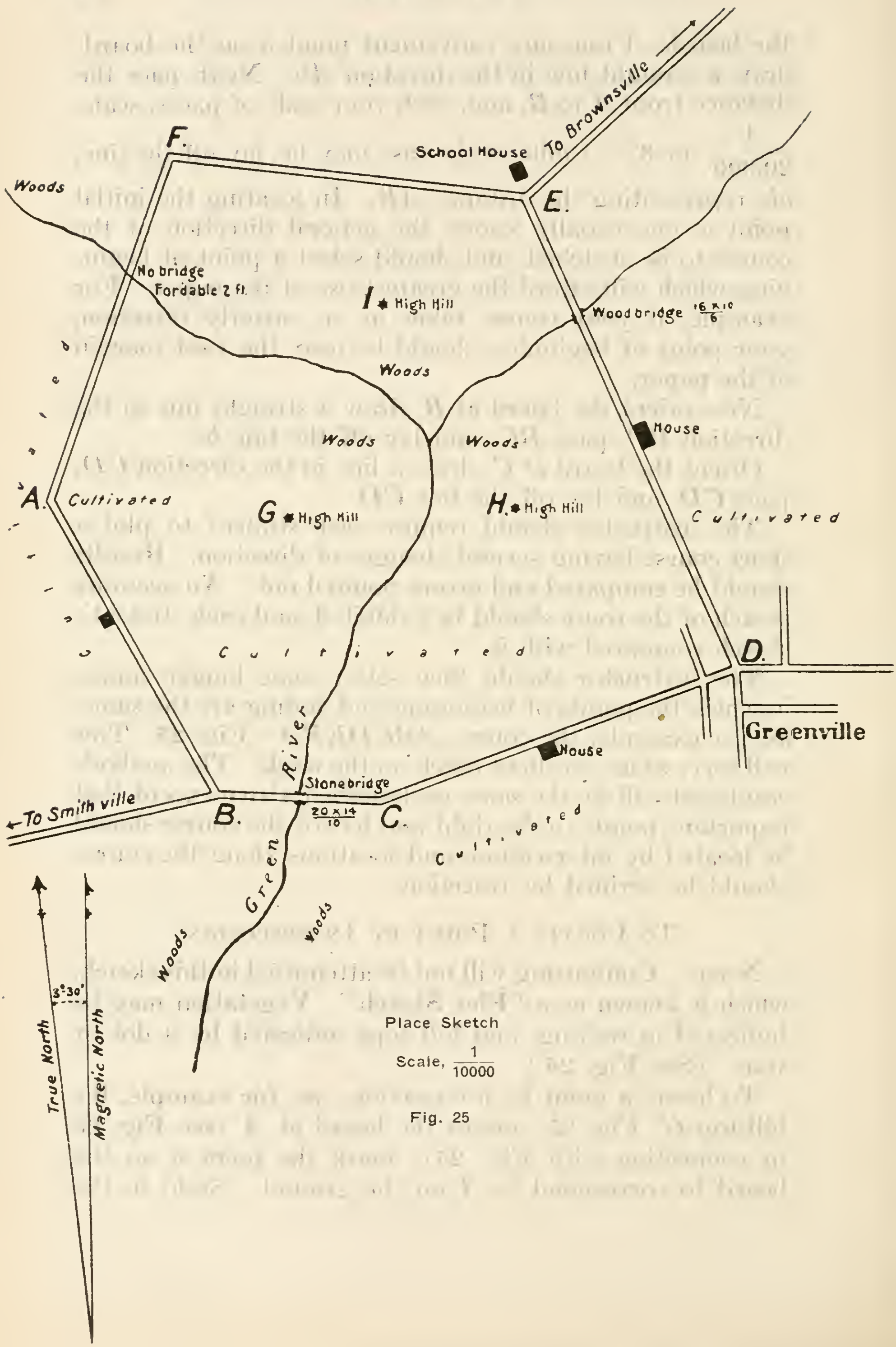

To Brownsville
F.
School House
E.
Woods
No bridge
Fordable 2 ft.
I High Hill
Wood bridge $\frac{16 \times 10}{6}$
Woods
House
Woods
Woods
A.
Cultivated
G High Hill
H. High Hill
Cultivated
Cultivated
D.
Greenville
House
River
Stonebridge
←To Smithville
B.
$\frac{20 \times 14}{10}$
C.
Cultivated
Green
Woods
Woods
3°30'
True North
Magnetic North
Place Sketch
Scale, $\frac{1}{10000}$

Fig. 25

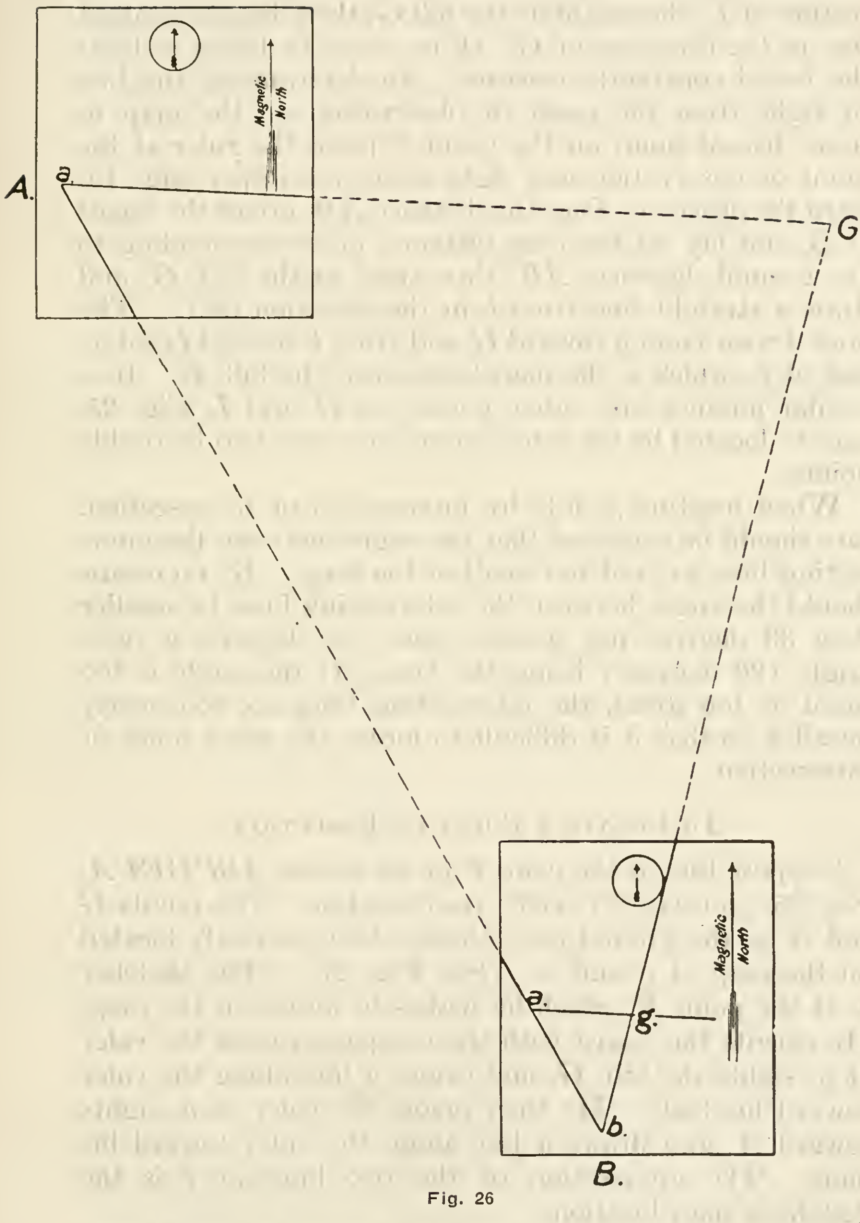


Fig. 26

direction of *B,* and from *a* draw a straight line in the direction of *B,* then sight at the hill *G,* then draw a straight line in the direction of *G.* (Care must be taken to keep the board constantly oriented. In determining the line of sight from the point of observation on the map to some distant point on the ground, pivot the ruler at the point of observation and sight along the upper edge toward the object.) Pace the distance *AB,* orient the board at B, and lay off the map distance, *ab,* corresponding to the ground distance, *AB,* then sight at the hill, *G,* and draw a straight line from *b* in the direction of *G.* The lines drawn from *a* toward *G* and from *b* toward *G* intersect at *g,* which is the map location of the hill, *G.* In a similar manner any other points, as *H* and *I,* Fig. 25, may be located by the intersection from any two favorable points.

When locating points by intersection or by resection, care should be exercised that the angles between the intersecting lines are not too small or too large. By no means should the angle between the intersecting lines be smaller than 30 degrees nor greater than 150 degrees, a right angle (90 degrees) being the best. If the angle is too small or too great, the intersecting lines are too nearly parallel, so that it is difficult to locate the exact point of intersection.

TO LOCATE A POINT BY RESECTION

Suppose that at the point *F* of the course *ABCDEFA,* Fig. 25, you wish to verify your location. The points *G* and *A* on the ground have already been correctly located on the map at *g* and *a.* (See Fig. 27.) The sketcher is at the point *F,* which he wishes to locate on the map. He orients the board with the compass, pivots the ruler at *g,* sights the hill, *G,* and draws a line along the ruler toward his body. He then pivots the ruler at *a,* sights toward *A,* and draws a line along the ruler toward his body. The intersection of the two lines at *f* is the sketcher's map location.

As the sketcher passes over the course, he should note

in writing on his sketch such ground features as bridges, fords, ferries, houses, woods, cultivated fields, villages, high hills, streams, or any other information of importance. (See Fig. 25.) As stated before, the sketch shown in Fig. 25 is known as a "Flat Sketch," no relief being shown.

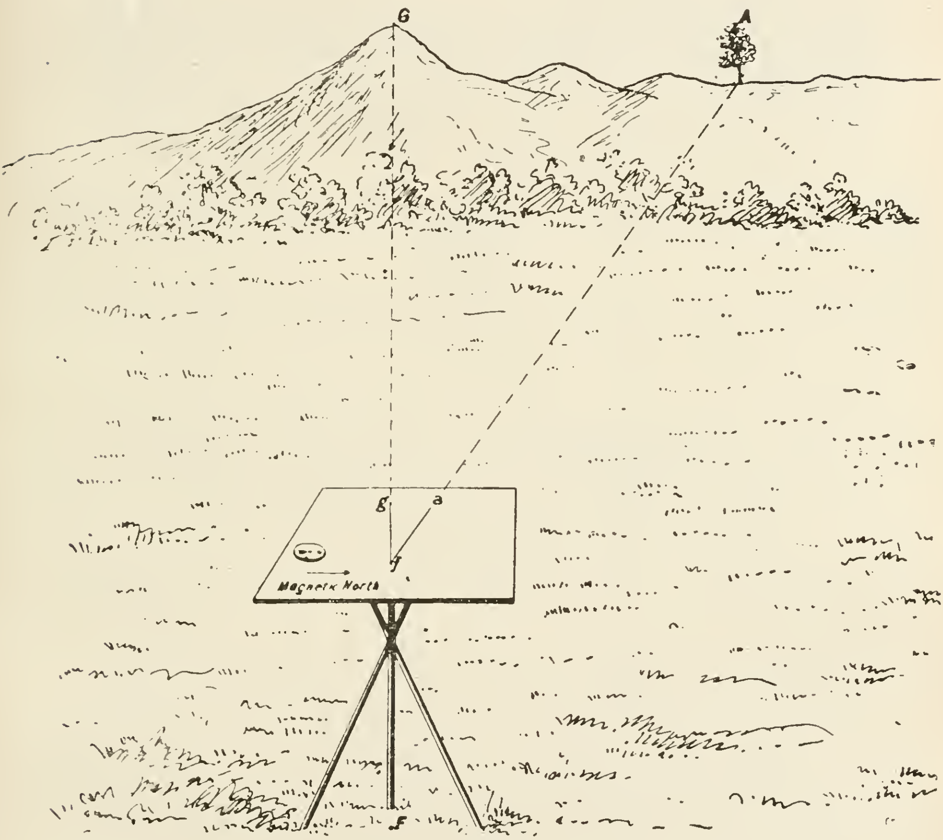


Fig. 27

When completed, the following information should be indicated at some convenient place on the sketch:

1. Location of sketch.
2. Name and organization of sketcher.
3. Date of sketch.

4. Scale of sketch.

5. The magnetic north, and, if the declination of the needle is known at the particular locality, the true north should be indicated also.

6. Reading scale.

7. Contour interval.

8. Scale of map distances.

Nos. 7 and 8 need not be indicated unless the sketch is contoured.

Lesson XI

Method of Determining Difference of Elevation

Construction of the Slope-Board

On your drawing board (see Fig. 28) construct DC perpendicular to AB, then, in sighting at a point along the top edge, AB, the plumb-line attached at D makes the same angle with DC, the perpendicular line, as AB

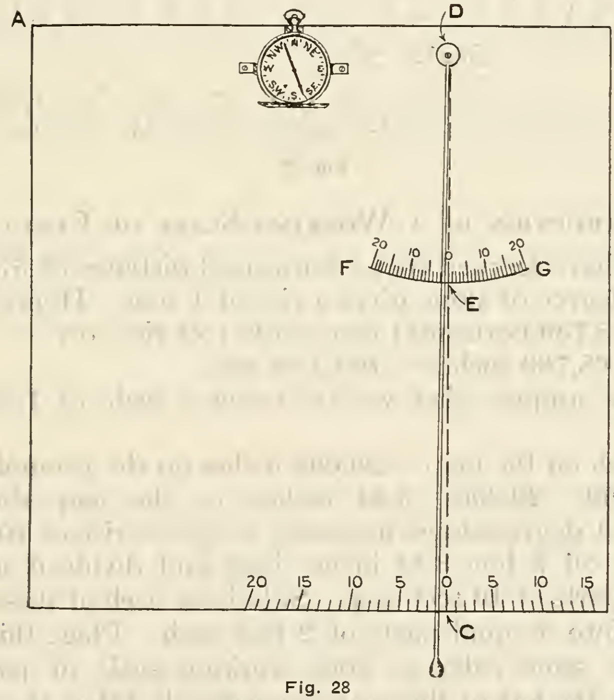


Fig. 28

makes with a horizontal line. This, of course, assumes that your drawing board is perfectly square.

With a radius DE equal to 5.73 inches describe the arc FG. Then to the right and left of E divide the arc into divisions of 1/10 inch each. Each one of these divisions is

equal to one degree. (This is based upon the fact that, with a circle of 5.73 inches radius, each degree is subtended by an arc of 1/10 inch.) With a ruler pivoted at *D* prolong the divisions to the foot of the board, as shown in the figure.

In reading slopes, a plumb-line is suspended at *D,* and the board is held in a vertical position as the observer sights at the object along the top edge of the board. Hold the board steadily, and, when, the plumb-line stops swinging, press it against the board with the finger and read the angle.

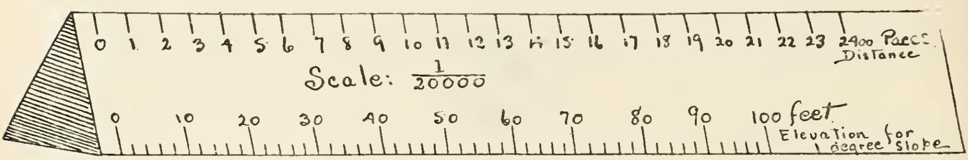


Fig. 29.

CONSTRUCTION OF A WORKING SCALE OF ELEVATIONS

We have learned that a horizontal distance of 57.3 feet for 1 degree of slope gives a rise of 1 foot. Hence:

5,730 horizontal feet = 100 feet rise; or,

68,760 inches = 100 feet rise.

Now suppose that we are using a scale of 1/20,000, then

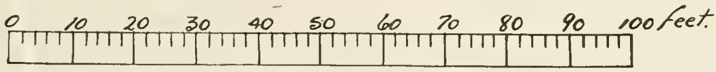
1 inch on the map = 20,000 inches on the ground.

68,760 ÷ 20,000 = 3.44 inches, or the map distance, with a 1 degree slope, necessary to give a rise of 100 feet.

Lay off a line 3.44 inches long and divide it into 10 equal parts of 10 feet each. Subdivide each of these equal parts into 5 equal parts of 2 feet each. Place this scale on the same ruler as your working scale of paces or strides, the left of this scale immediately below the left of your working scale of paces or strides. (See Figure 29.)

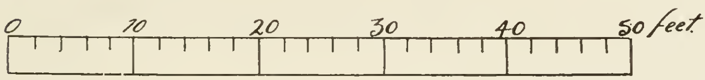
Now suppose that you have paced a course 500 paces long with a 3-degree slope. Lay off the distance, 500 paces, from your working scale of paces (the upper scale), then glance at your scale of elevations immediately be-

low the 500 point on the upper scale, and you have the elevation for a 1-degree slope; multiply this result by 3 and you have the difference in elevation between the two points considered.



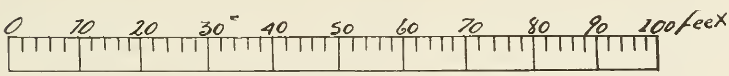
SCALE OF ELEVATIONS FOR 1-DEGREE SLOPE

Scale: 3 inches equal 1 mile



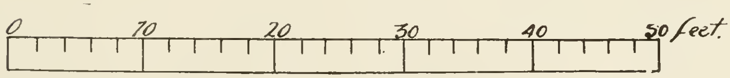
SCALE OF ELEVATIONS FOR 1-DEGREE SLOPE

Scale: 6 inches equal 1 mile



SCALE OF ELEVATIONS FOR 1-DEGREE SLOPE

Scale: $\frac{1}{20000}$



SCALE OF ELEVATIONS FOR 1-DEGREE SLOPE

Scale: $\frac{1}{10000}$

Fig. 30.

To construct a scale of elevations for a scale of 1/10,000, the map distance necessary to secure a rise of 100 feet would be just twice as great, or, in other words, the map distance on your scale 1/20,000 necessary to give a rise of 100 feet (3.44 inches) would give

you a rise of 50 feet with a scale of 1/10,000. Hence, you would divide the line into 5 equal parts of 10 feet each, and subdivide each of these parts into 5 equal parts of 2 feet each.

Similarly, if your scale were 3″ = 1 mile, you would divide 68,760 by 21,120, which would give you a distance of 3.25 inches necessary to give a rise of 100 feet. With a scale 6″ = 1 mile, this distance would give you a rise of 50 feet. The construction of the scales would be the same as noted above.

On preceding page (see Fig. 30) are given scales of elevations for the following scales: 1/20,000, 1/10,000, 3″ = 1 mile, 6″ = 1 mile. All that will be necessary is to transfer the scale of elevations underneath your corresponding scale of paces.

Assuming that each student is now equipped with a combined working scale of paces and elevations, the instructor should take the class to some suitable point where each can pace the distance to some elevated point, read the angle of slope, and, with the auxiliary scale of elevations, determine the elevation. The student should be watched carefully, in order to see that he holds the board correctly in reading angles of slope, and that he thoroughly understands the use of both working scales.

Lesson XII

Exercises in Contouring

We should now have a very good idea of what contours are and how to determine the elevations of locations by means of our scale of elevations.

Before taking up the subject of sketching, much may be learned about contouring the ground to be sketched by working out the exercises suggested in this lesson. In actual sketching, the contour lines are entirely drawn in by eye, first having given or assumed the elevation of a certain location of the ground to be sketched as a datum plane, and also having outlined the drainage by means of stream lines and elevations of certain controlling points. These controlling points are commonly called *critical points.* Critical points, as applied to contours are points indicating an abrupt change of elevation, as the top of a hill, or an abrupt change in the slope of the hill, also the head and foot of a ravine or water course, the junction of stream lines, etc. Having previously located on your sketch the stream lines and critical points—in other words, thoroughly outlined the drainage of the area—you should proceed to as many of these critical points as will be necessary to obtain a view of the entire area; usually two or three will prove sufficient, and you will find that from these points all of the contour lines may be drawn in by eye with a surprising degree of accuracy.

Figure 31 illustrates the idea. Without even seeing the area, one is able, by means of the stream lines, dry water courses, and elevations given, to draw in the contours about as they would appear if this sketch were actually completed on the ground. In drawing in the contour lines, the student should bear in mind the principles of contouring given in the lesson on relief maps. Each student should draw in the contours on this sketch with a soft pencil and then compare the results. This exercise will impress upon the mind the importance in sketching of first carefully outlining the drainage of the area to be sketched.

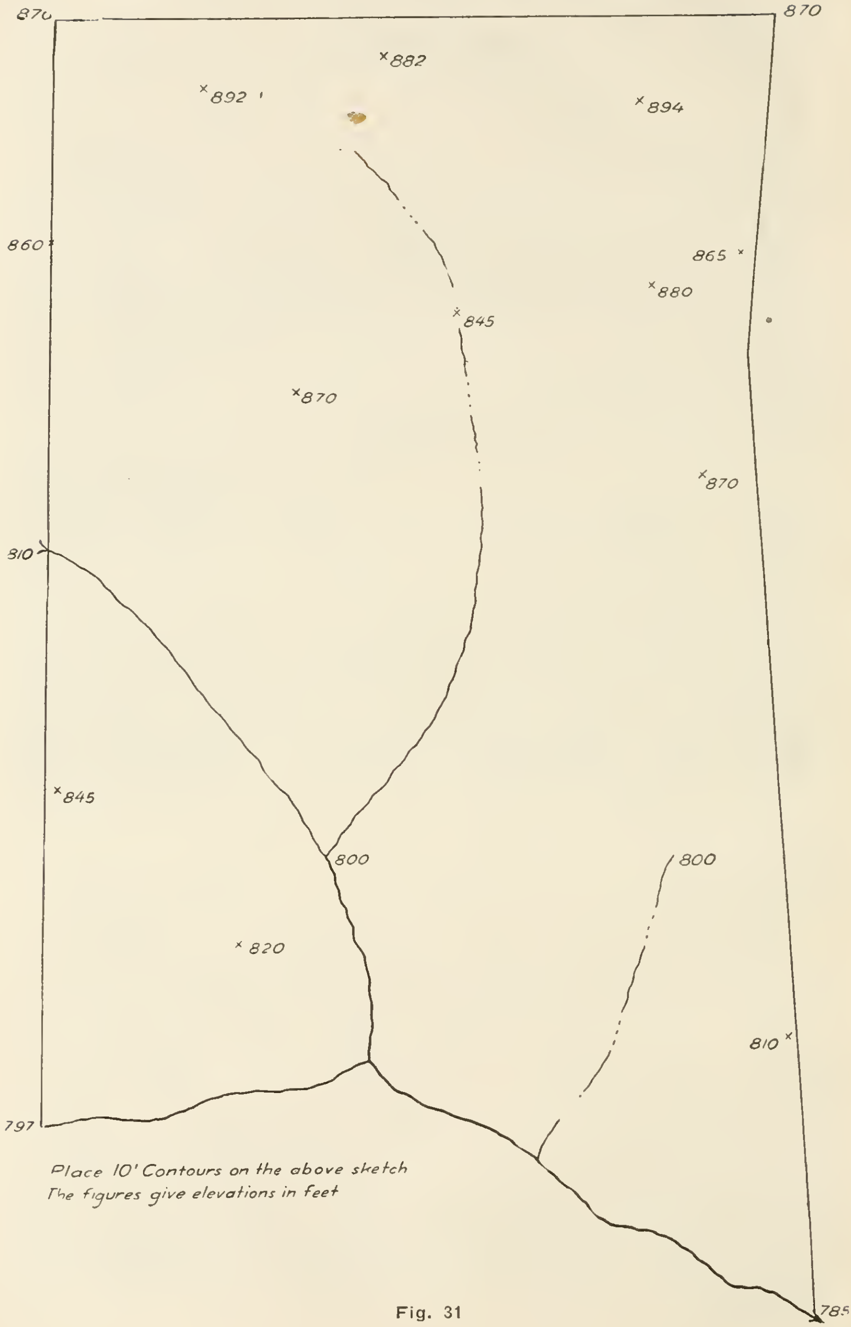

870
870
882
892
894
860
865
880
845
870
870
810
845
800
800
820
810
797
785
Place 10' Contours on the above sketch
The figures give elevations in feet

Fig. 31

Students should be given tracing paper and contoured maps with instructions to trace upon the paper the stream lines and elevations of critical points, then remove the tracing paper from the map, and interpolate the contours, afterwards comparing the contours interpolated with those of the original map.

One may obtain a great variety of these control sketches from the Book Department, General Service Schools. Order a complete set of them which will cost but a few cents, and then make mimeograph copies for use of the class.

It will be found that, by the methods suggested above, the student will soon obtain a very accurate idea of what points are really critical in correctly contouring an area, and, when he begins to sketch, these points will stand out vividly on the terrain before him.

PROBLEM

The point *A*, on a map, scale 1/20,000, has an elevation of 780 feet. Given the azimuth and a distance from *A*, and the elevation of the following points:

Point	Azimuth, degrees	Distance from A, yards	Elevation, feet
B	20	1,000	920
C	35	500	865
D	50	800	820
E	70	300	820
F	75	1,200	920
G	90	800	840
H	110	500	785
I	115	1,000	890
J	125	700	780
K	150	400	745
L	160	1,100	700
M	180	600	780
N	200	900	845
O	220	400	800
P	245	1,000	895
Q	270	900	860
R	290	400	None given
S	320	800	880
T	340	300	810
U	355	900	840

A stream flows in the general direction *U-A-K-L.* A branch of this stream flows in the general direction *D-K,* passing midway between *E* and *H.* Another branch in the direction *R-A* flowing for some distance in the same general direction. The latter branch has a uniform slope of one degree.

From the notes given above, plot the stream lines and critical points given and interpolate the contours so as to make a possible representation of the relief under the conditions given. Remember that a map, scale 1/20,000, under the normal system has a V. I. of 20 feet.

NOTE.—All information necessary in the solution of this problem has been given in this lesson and in the lessons preceding it.

Lesson XIII

Sketching the Relief of a Small Area

It is assumed that the student now has his sketching implements complete, viz.—

1. A drawing-board (with tripod, if desired).
2. Scale of paces with an auxiliary scale of elevations.
3. Compass.
4. HB, or other soft pencil, and eraser.
5. Knife or pencil sharpener.
6. Paper and thumb-tacks.

The only basic principle of sketching not yet actually practiced by the student is the process of actually locating critical points and determining their elevations, and, bear in mind, that this is the keynote to sketching. From the exercises in contouring given in the last lesson, the student should have an excellent idea of the nature of critical points.

The instructor should designate some area of about a quarter of a square mile possessing a well-defined drainage system, and require the student to traverse around it, locating the important critical points and determining the elevations. These critical points, as heretofore stated, are conspicuous hill tops, abrupt changes in the slopes of hills, junctions of stream lines or dry runs, abrupt changes in the course of stream lines or dry runs, or, in other words, enough data to outline thoroughly the drainage of the area. After this work is completed the students should be grouped at some good point or points of observation, and required to sketch in the stream lines and contours as described in the previous lesson. After the work is completed the sketches should be compared with some good map of the area, or with the terrain itself, with a view of pointing out errors.

Lesson XIV

Road Sketch

We have learned how to plot on the map ground distances, directions, elevations, and the various natural and artificial ground features of military importance.

We will now make a complete road sketch, scale 1/20,000. The instructor should designate some road; a course of about two miles with several changes of direction is sufficiently long for the beginner. Each student will go over the designated road, plotting distances, directions, elevations, and important ground features.

The sketch should not only include the road itself, but an area extending about a quarter of a mile each side of the road. As a rule, most of this area may be seen from high elevations along the road bed, but occasionally it may become necessary to go to an elevated point outside the road proper to secure all of the details. Objects of military importance, such as high hills, towns, etc., which are more than a quarter of a mile from the road, should be located by intersection. Whenever hills are located by intersection, their elevations should be noted.

The most practicable method of indicating details on sketches made in the field is shown in Fig. 32. Vegetation, especially, should be indicated by words rather than by the proper conventional signs. In short, the best field method is the shortest and most accurate method. In order that the student may become familiar with all of the conventional signs, which is very important when it comes to map reading, the field sketches may be retouched at leisure, employing the proper conventional signs in each case. The beginner should sketch in every detail of military importance in order to train the eye to observe details. Later he may be called upon to submit sketches showing only such information as may be required for particular expeditions.

After the field work has been completed, the instructor

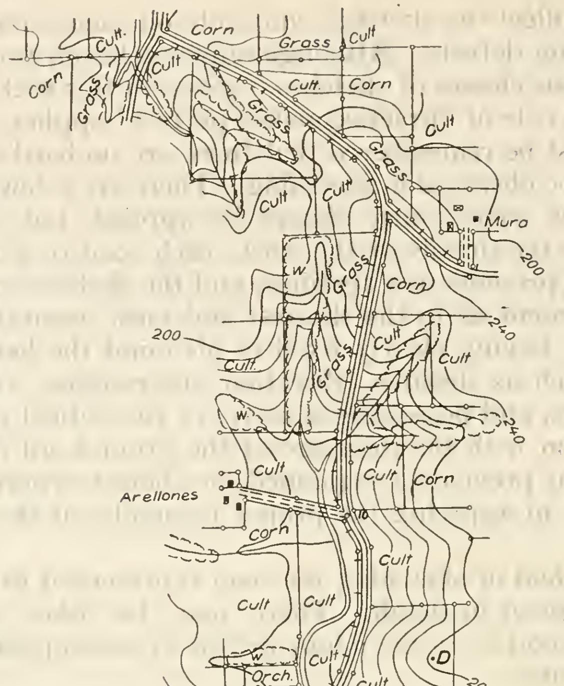
should collect the sketches, and note on each sketch all of the glaring defects. Although only one lesson for each of the various classes of sketches is given in this text, yet the same old rule of "practice makes perfect" applies.

It must be remembered that there are no hard and fast rules to be observed in sketching. There are a few general principles which must always be applied, but, when it comes to the details of the work, each road or area to be sketched presents new features, and the sketcher must use his judgment as to the shortest and most accurate methods; but, having clearly fixed in his mind the basic principles such as distance, direction, intersection, resection, elevations, and possessing a keen eye for critical points in connection with the drainage of the ground, all of which have been previously explained, he should experience no difficulty in applying the proper principles at the proper time.

A method of sketching the road represented in Fig. 32 will be given in detail. There may be other methods equally good as to the minor details of accomplishing the same results.

You are directed to sketch the road beginning at the bridge near the Langford house, thence about two miles to the north, Fig. 32. It will be noted that this road has frequent changes of direction, which will require more "Set ups" than in the case of a more direct route. It is assumed that the elevation of the floor of the bridge is 90 feet. In case the elevation of the point of beginning is not known, it always may be assumed, and your elevations will be relatively correct throughout the sketch.

Orient the board at 1, and indicate your magnetic meridian as explained heretofore. Sight in the direction of 2 (the first change of direction in the road), and draw a straight line in the direction of 2. Then proceed to 2, and on arriving there you have determined the distance. Note down the location of 2, and, from points 1 and 2, plot in such details as the stream, railroad, buildings at the Langford house, etc. Continue the work along the same lines at 3, 4, 5, 6, 7, 8, etc.



Road Sketch,

Scale, $\frac{1}{20000}$

V. I. 20′

Fig. 32

Now the subject of contours comes in. If the correct methods are pursued, the contouring will be found to be very simple and interesting. Do not attempt to get the angles of slope to 2, 3, 4, and 5, as the change of elevation is so slight. Remember the principles of contouring brought out in previous lessons.

Bearing in mind those principles, what are the critical points which determine the drainage of this route? They are 1, 6, and the stream crossing north of 8, also *A, B, C,* and *D*. How are those elevations determined? Intersect on *A* from 1 and 6, then, knowing the elevation of 1, the elevations of *A* and 6 are determined by methods previously explained. Intersect on *B* and *C* from 6 and stream crossing north of 8, and so on throughout the sketch. Never attempt to determine the slope at each change of elevation in the road. It is an endless task, your error multiplies, and in a short time you have lost control of your relief entirely.

Then, having determined the elevations of the three stream crossings and *A, B, C,* and *D,* and noting, as you pass along the road, the direction of the stream lines and the general directions of the spurs leading down from the hill tops, you can not go far astray in interpolating your contours from good observing points along the road-bed or in close proximity thereto.

A Few Rules to Be Observed by the Beginner

1. Go at your work deliberately and coolly, orient your board carefully at each station, and always check the orientation before making observations or drawing lines.

2. With the board oriented, sight carefully before drawing lines indicating direction. The same applies in determining degrees of elevation with the slope board.

3. Do not spoil your map by putting in a mass of unessential details. In fact, if you get your distances, directions, elevations, and locations of critical points, you will find that, from conspicuous points of observation, you will be able to draw in the essential details, including the contours.

4. Do not put in too much time on one portion of your sketch to the neglect of the remainder.

5. Before leaving a station see that your sketch is complete in the essentials outlined above.

6. Be sure that the drainage has been properly outlined before attempting to trace in the contour lines, in other words, first locate conspicuous hilltops, the direction of spurs leading therefrom, and the course of stream beds and valleys. This is most important, as the drawing in of the contour lines without first indicating what may be called the framework of the drainage would be like fitting a garment without making previous measurements.

7. In all classes of sketches it is very necessary that the sketcher be able to estimate distances with a considerable degree of accuracy. It is assumed that an expert rifleman can estimate distances with less than ten per cent error up to 600 yards, and with less than 15 per cent up to a mile. This is equally true with the expert sketcher.

8. There are many short cuts that the sketcher of experience discovers and applies. Such short cuts are always permissible and add to the efficiency of the sketcher so long as they do not interfere with the accuracy of the map.

Lesson XV

Position and Outpost Sketches

In accordance with the terminology employed at our General Service Schools and in War Department orders, sketches are divided into two general classes: *Road Sketches* and *Area Sketches.* The former we have already discussed. The latter is divided into three classes of sketches:

1. Position Sketch, or, in other words, a sketch of a comparatively small area such as might be occupied by troops as a camp site, aviation field, or for almost any special military purpose.

2. Outpost Sketch. This sketch is of great importance in military operations, as, for example, when a battalion occupies a front line position, the battalion commander must show the disposition of his outpost line either by locations on a map provided, or, in the event that none is provided, by a complete topographical sketch including his dispositions.

3. Place Sketch. As the name indicates, this sketch is made from one observing point, as, for example, by a member of the Intelligence Platoon from an observation post (O.P.).

All three sketches are made on a scale of $\frac{1}{10,000}$ as recently authorized by the War Department. However, in some cases they may be made on a different scale in order that they may be embodied as a part of existing maps. In making a position sketch the base line may be run over the most suitable line anywhere within the area. On the other hand, in making an outpost sketch, the base line would have to be in rear of the friendly line of observation, and points in the disputed or hostile area would be located by intersection or observation, while with the place sketch, the sketcher can only take bearings and determine approximate locations by estimating distances.

In this lesson we will consider the position sketch and the outpost sketch. The work involved in making these sketches naturally divides itself into two operations:

1. The framework, or a triangulation scheme.
2. Filling in the details.

In the construction of the framework there are three steps:

(*a*) Estimating the situation. Go to the best point of observation possible, decide upon the location of a base line, note the critical points within the area, and the lines to be traversed if necessary.

(*b*) Measure the base line.

(*c*) Locate by intersection as many of the critical points as possible.

In filling in the details, you may find it necessary to traverse a certain route in order to locate certain vital critical points or for other reasons. However, as soon as you find that you have a good control map or framework, go to some good point or points of observation and complete the sketch by filling in, by observation, the remaining topographical details and contour lines.

Many experienced sketchers may have other methods of approaching the work, but the method outlined above is a practicable one for the beginner, from which he may depart in some particulars as he becomes more experienced. The nature of the terrain to be sketched is also a factor in the methods to be pursued.

BASE LINE

The mapping of areas, either by hasty sketching methods, or by means of an accurate instrumental survey, depends primarily upon some system of triangulation. By triangulation is meant the establishing of a series of triangles covering the area to be mapped, by means of which critical points are located horizontally and vertically. As heretofore stated, the angles of these triangles should not be less than 30 degrees nor greater than 150 degrees.

The base line should be located as near the center of the area as practicable, but the lay of the land is the im-

portant factor in its location. It may be found necessary to locate the base line near to one side of the area, or, in some rare cases, entirely outside the area. Its length also depends upon the lay of the land and the visibility at its extremities. No fixed rule as to the proper length of a base line for small areas in hasty sketching could be given more than the necessity of a sufficient length to locate critical points throughout the area, that is, so that the intersecting lines will form angles greater than 30 degrees. As a very general rule the base line should be from 1/3 to 2/3 of the length of the greatest dimension of the area. It should be on as level ground as possible with its ends well defined by natural or artificial objects. In hasty sketching the base line is measured by pacing, exercising as much care as possible. It is obvious that the accuracy of the sketch depends upon the measurement of the base line.

The horizontal and vertical positions of the vertices of the Triangles are located either by intersection or resection. (See Fig. 33 and Fig. 34.) Points 1 and 2 locate the extremities of the base line. Points 3 and 4 are located by resection, and points *A*, *B*, *C*, *D*, *E*, *F*, and *G* by intersection.

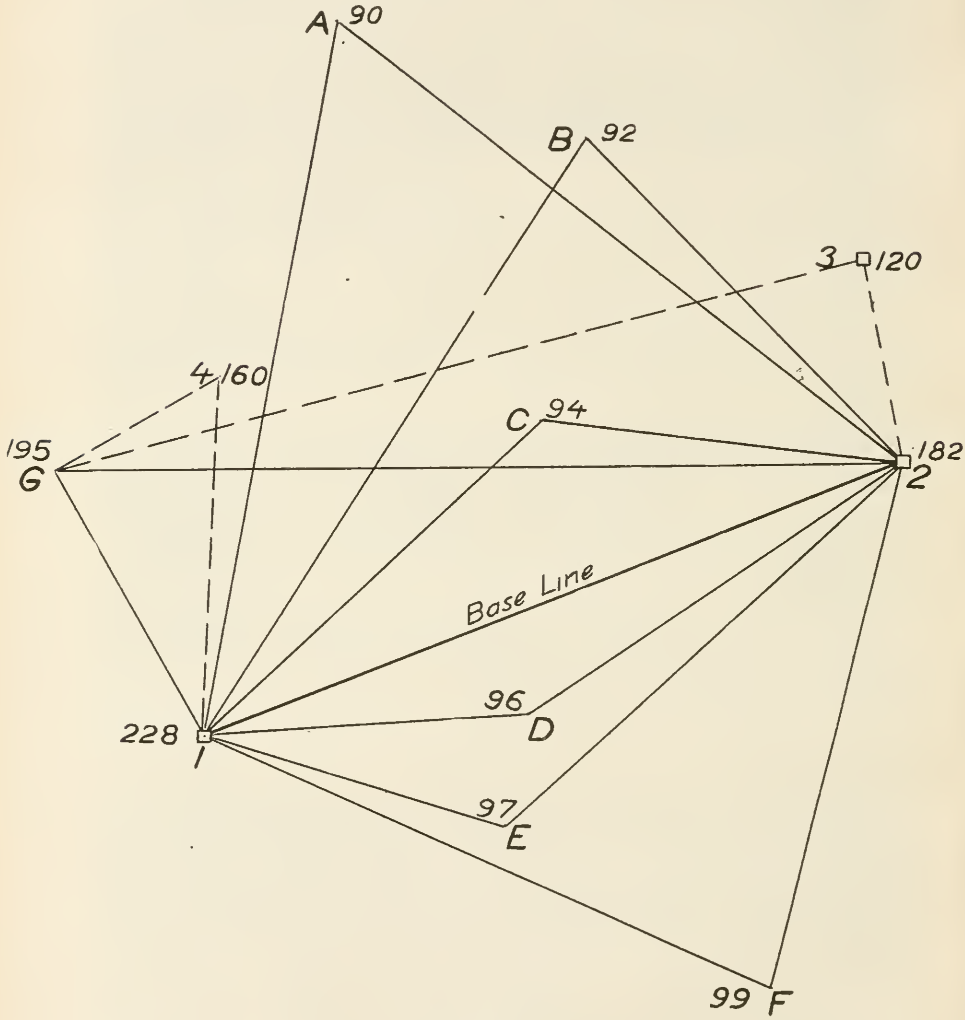
Method of orienting, determining distances and directions, the location of points by intersection and resection have been previously explained. In view of this, it will not be necessary to go into detail in explaining the method of operations pursued in obtaining Fig. 33, which is the triangulation scheme involved in the position sketch shown in Fig. 34. A brief description of methods pursued in the position sketch shown in Fig. 34 will be given, however, in which the terms used in this paragraph will be used freely without further explanation.

Method in Detail of Sketching Position Sketch, Fig. 34

Assume that from some good observing point you have selected the line, 1-2, as the base line. You are given the altitude at 1, or the altitude may be computed from some

nearby bench mark, or the altitude of 1 may be assumed. In this case we will assume that the altitude at 1 is 228 feet.

Set up and orient at 1. Draw a straight line in the

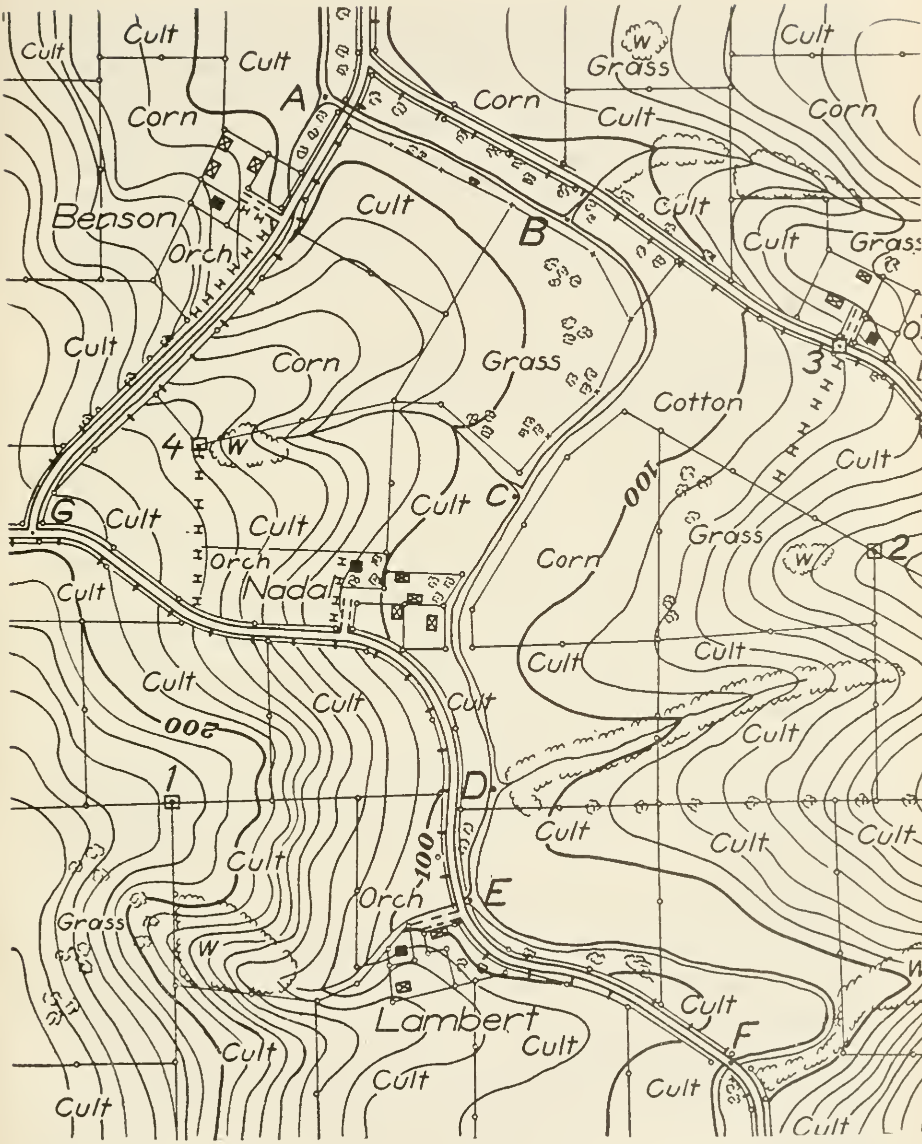


Frame Work

POSITION SKETCH

Scale, $\frac{1}{10000}$

Fig. 33



POSITION SKETCH

Scale, $\frac{1}{10000}$

V. I. 10[1]

Fig. 34

direction of 2, also determine the angle of slope from 1 to 2. Before leaving, draw radiating lines to as many critical points as will assist you in outlining the drainage of the area. The nature of these points has been explained in previous lessons. In selecting the critical points, select such points as will probably be seen from 2. Next, pace the distance to 2. In doing so, note the distance to the road and to the stream, also the elevation of each of these points. Arriving at 2, lay off the distance and note the elevation of 2, and set up. At 2 complete the intersection of points sighted from 1, and note the elevations of these points. Next, proceed to the road near by, and locate your map position either by resection or by traversing the distance, then traverse the entire road, following out methods suggested under "Road Sketch" in the previous lesson. Then by setting up at a few good observation points such as 1 and 2, and possibly some others, and aided by the traverse and critical points located, you are able to complete the sketch from observation, filling in the remaining topographical details, and interpolating the contours as suggested in previous lessons.

One of the greatest assets to the sketcher is an eye for critical points. *Remember that the correct location of the critical points determines the drainage of the area, and with the correct drainage established, you have the key to the sketch.*

The sketcher soon discovers many short cuts in the work. Every area to be sketched is different, and requires a brief estimate of the situation from some good observing point before taking up the work in order to take the greatest advantage of the terrain. However, by following out the suggestions of this lesson, the beginner will not go astray, and, with experience, the short cuts will dawn upon him.

OUTPOST SKETCH

The general plan of making an outpost sketch is the same as with the position sketch, with some few exceptions as follows:

The base line must be along the line of observation or a sufficient distance in rear with a view of locating as many points along the line of observation as possible, these latter points to be used in locating points toward the hostile position either by intersection or observation. In making an outpost sketch, it is usually impossible to visit that portion of the area beyond the line of observation, hence all points beyond this line must be located either by intersection or observation.

In addition to the topographical features of military importance, the locations of the various parts of the outpost should be indicated. In this connection, the student should consult the Field Service Regulations.

Lesson XVI

Place Sketch

It is often necessary to sketch a certain area from one point of observation. This is called a "Place Sketch." It consists of bearings on critical points or points of tactical importance, and the estimation of distances and elevations pertaining thereto.

Patrol leaders and members of Intelligence Platoons, in time of war, will frequently find it necessary to make Place Sketches. In fact sketches of this nature are constantly being made at observation posts, either in the form of overtracings on maps already provided or as separate sketches.

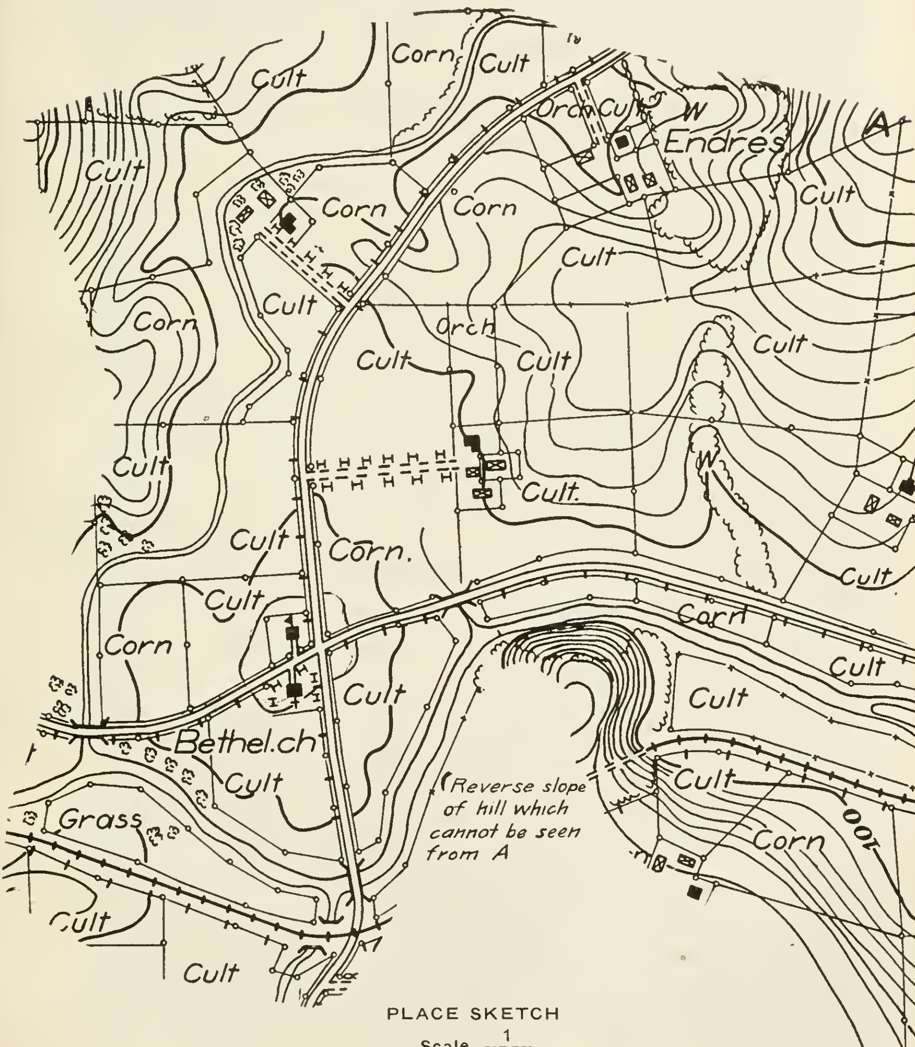
The correct estimation of distance is a very important factor in making place sketches. The rifle sight and mil scale are valuable aids in this connection. Telegraph poles, telephone poles, fence posts or any artificial objects placed at fixed distances should be considered in the estimation of distance. In many parts of the United States the roads divide the country into sections of one square mile each, and these sections are likewise divided by fences into fields of which one may readily estimate the dimensions.

As the estimation of distance is made in yards, a scale of yards, 1/10,000, is necessary. A scale of yards, 1/20,000 and 1/10,000, should be inscribed on every working scale as they are frequently needed, it being necessary to estimate distance in all classes of sketches.

You are in charge of a patrol operating in hostile territory. Your patrol is concealed at some point north of *A,* Fig. 35. You proceed to the high point *A,* and discover that a hostile force consisting of one infantry battalion is going into camp at Bethel Church. It is assumed that you are in hostile territory, and that you have no good maps of this particular terrain, as often may be the case. In that event, the message that you are about to send will

be of much greater value to your commanding officer if accompanied by a sketch.

As it is obvious the entire sketch must be made from the one point of observation, *A*, hence the term, place sketch. It is also obvious that the entire sketch must be made from observation. Sketches of this class are hastily made on the back of the message forms furnished organizations in the field.



PLACE SKETCH

Scale, $\frac{1}{10000}$

V. I 10′

Fig. 35

First orient your message book, then look over the area to be sketched, and endeavor to locate some feature or features of the terrain which will best serve the purpose of a frame work upon which to connect up the remaining details of the area. Roads, if available, will answer the purpose very well, especially where there are telephone poles. In this case, by the aid of the telephone poles, and rays drawn to the various critical points of the area, a fairly accurate framework may soon be established upon which the remaining topographical features may be connected up.

As to the contour lines, assume as the datum plane the downstream end of the largest stream, and, for convenience, call this elevation zero, or assume some elevation for your lowest contour as 100 feet, as is the case in Fig. 35. Then compare your own elevation with that of the datum plane and other critical points which have been located by rays drawn from *A* and estimation. It only remains then to interpolate your contours in the same manner as was explained in discussing the position sketch.

Here is an instance where field glasses come into play, not only in picking up important details, but the attached mil scale is used in the estimation of distance. When good maps are available, which is usually the case, the Place Sketch is about the only sketch that one on duty with troops in combat would be called upon to make, and almost any one, from the commanding general down, might find it necessary to draw, from one point of observation, a hasty sketch consisting of simply a series of radiating lines from the point of observation to points occupied by the enemy or of other tactical importance. The point of observation should be identified in its relation to some well-defined point of the map in use. The estimated distance should be noted on the radiating lines, and the points located should be described briefly, as, for example, Machine Gun Nest, Hostile Observation Post, etc.

As an exercise, the following is suggested: The instructor will post each member of the class in the same locations as he might the outguards of an outpost, and

require each student to make a place sketch, including a certain well-defined sector in front of his position. When the sketches are completed, the instructor, accompanied by the entire class, will proceed in turn to each of the positions occupied by the sketchers. Members of the class, other than the sketcher who occupied the position, will be required to orient the sketch and check the distances and directions, and, in fact, review the entire sketch. By this method many points will be brought out, and, at the same time, each student will be keen to do his best, knowing that his work is to be reviewed by the entire class.

A keen eye for critical points, the correct estimation of distances, and speed are qualities that a good place sketcher must possess.

Lesson XVII

Combined Sketches, Reconnaissance Reports, Map Reproduction

Commanding officers operating in regions which have not been mapped usually find it necessary to produce some map upon which to base their operations or activities until such time as an authoritative map can be made. Such a map is usually a compilation of individual area sketches made on a scale suitable to the activities involved, and is called a combined sketch.

The only new factor in combined sketching is the boundary line between individual sketches. The entire area to be sketched should be divided as equally as possible among the available sketchers. The boundary lines between individual sketches should be well defined, such as roads, stream lines, etc., and the two sketchers concerned over any particular boundary should do the field work together. In other words, their work should agree in every detail. If such a course were not pursued, the draftsman in the office would have to use his own judgment in coordinating the work of the various sketchers which would obviously result in many errors.

The commanding officer should select a chief of sketchers capable of organizing the work in every detail, as much depends upon the organization when it comes to rapidity and accuracy of the work as a whole.

In a similar manner, maps may be enlarged, as, for example, you have a Geological Map, scale 1/62,250, which you wish to use as the basis for making a training map, scale 1/20,000. In this connection there is a certain amount of field work to be done. The Geological Map may be obsolete in many respects, and, of course, the training map would include many more details than is shown on the Geological Map.

Divide the area to be sketched among the sketchers, employing well-defined boundaries as in making an original

sketch. Then, on individual sheets, have a draftsman enlarge to 1/20,000 such basic features of the Geological Map as are permanent, viz.—the relief-contours, stream lines, and also such roads as are known to be correct. Thereafter the same method of procedure is employed as in making an original combined sketch.

Where there are no training maps, but Geological maps are available, the commanding officer might employ the time of junior officers very profitably in completing training maps as described above. There is no better instruction in familiarizing officers with terrain features. For printing, divide the area into sheets of 20,000 by 12,000 yards as prescribed in Army Regulations for training maps. Detail the best draftsman to make the tracings. Grid the maps as previously described in the text, and then make arrangements with the Secretary General Service Schools for printing. It is believed that the capacity of the map-reproducing plant at the General Service Schools is such that the work could be done at a very reasonable price.

There is a possibility that the work might be done by the Engineer Department of the Army as prescribed in Army Regulations, but, if funds are not available as is quite often the case, the work may be done as outlined above with slight cost, and, at the same time, the junior line officer receives valuable instruction.

TOPOGRAPHICAL RECONNAISSANCE REPORTS

A topographical reconnaissance usually consists of a sketch and a report. As many of the required details as possible should be shown on the sketch. Additional information, such as would be required, may be shown in marginal notes on the sketch, or, if this is not found to be practicable, a separate report may be made and appended to the sketch.

The report should be as brief as possible consistent with rendering all of the desired information. Frequently sketches do not contain a sufficient number of reference points upon which to base a concise report, or to formulate a concise field order. If such is the case, additional reference points, such as letters or numbers, should be

added to mark road crossings, etc. Conspicuous hill tops and road crossings are commonly indicated by their elevations. These reference marks should be clearly indicated, and, on a sketch in connection with a report, they may be indicated in red or some other bright color that will immediately attract the reader's attention.

The following pertaining to field orders is quoted from the Field Service Regulations, and apply equally as well in Topographical Reconnaissance Reports:

"Field orders must be clear and definite. Expressions depending upon the viewpoint of the observer, such as right, left, in front of, behind, on this side, beyond, etc., are avoided, reference being made to the points of the compass instead. The terms right and left, however, may be applied to individuals and bodies of men, or to the banks of a stream; in the latter case the observer is supposed to be facing down stream. The terms right flank and left flank are fixed designations. They apply primarily to the right and left of a command when facing an enemy, and do not change when the command is retreating. The head of a column is its leading element, no matter in what direction the column is facing; the other extremity is the tail.

"To minimize the possibility of error, geographical names are written or printed in ROMAN CAPITALS; when spelling does not conform to the pronunciation, the latter is shown phonetically in parentheses, thus: BICESTER (Bister), GILA (Hee'la).

"When two or more places or features on the map have the same name they are distinguished by reference to other points.

"A road is designated by connecting two or more names of places on the road with dashes, thus: LEAVENWORTH-LOWEMONT-ATCHISON road."

There are as many classes of topographical reports as there are demands for sketches, each case differing slightly according to the particular information desired, but always coming under a few general headings such as the reconnaissance of a road, a railroad, a river, camp sites, positions to be occupied by troops, etc.

Road Reconnaissance Report

In addition to the information shown on the road sketch, the report might elaborate on such points as the following: steep grades, width of roadway; if paved, the width, class, drainage, and condition of paving; if dirt road, its soil and general condition. Can foot troops march along its side between the wagon track and fences? Advantageous infantry and artillery positions with range, etc.

Bridges: Complete information regarding piers, abutments and superstructure; width, clear head room, safe load, also the nearest bridge above or below with similar information.

Country: Any additional information pertaining to the vegetation or soil that cannot be shown on the sketch.

Streams Crossed: Additional information pertaining to streams crossed, such as width, depth, and surface velocity; velocity to be indicated as sluggish, moderate, quick, and swift; availability of water for various camp purposes; fords at or near crossing, with complete description of same; practicable for what class of shipping.

Towns and Villages: Name and location on sketch; material and size of buildings; distribution of buildings; population; location of depots, telegraph and telephone offices; water supply; sanitation; important public buildings and repair shops; food supply. In fact an exhaustive report would involve too many details to enumerate here.

Railroads Crossed: Name, gauge, single or double track, sidings, loading facilities, name and description of nearest station, etc.

Railroad Reconnaissance Report

In friendly territory all information necessary could be obtained from the proper railroad officials, but in hostile territory this information would have to be obtained by reconnaisance, and could be obtained better by an officer familiar with railroad conditions and the needs of the military service. Generally, the report would pertain to such matters as the following:

The Line: Name, terminal points, stations and dis-

tances between same, gauge, single or double track, ties, rails, condition of roadbed, drainage, liability to washouts, material and facilities for repairs, marching of troops on right of way.

Rolling Stock: Amount available for the particular section reported on; location of repair shops and their capacity; any other details depending upon the rolling stock.

Stations: Name and location; entraining and detraining facilities such as sidings; ramps, turn tables, water tanks, fuel supply, storage facilities, derricks, etc.

RIVER RECONNAISSANCE REPORT

General description of river valley as to limiting ranges, roads paralleling river, passes, infantry and artillery positions controlling river, and any other data not shown on the sketch.

The Stream: Its width, depth, velocity, navigability, any obstruction to navigation, information pertaining to high and low water marks, character of banks, quality of water, and source of contamination.

Canals: Width, depth, navigability, all information pertaining to the locks, means of destroying locks and the effect.

Bridges, Fords, and Ferries: For bridges, note the navigable width between piers, height of superstructure above water at the various water marks; with drawbridges, note dimensions and method of operation. Note the exact location of fords, length, width, and nature of bottom, practicability of troops crossing (see page 208, F. S. Regs.). Practicability of ferries for the various classes of troops, class of ferry, power. Data pertaining to all classes of shipping available in the river. Suitable defensive positions for bridges, fords, and ferries.

CAMP SITE AND POSITION RECONNAISSANCE REPORTS

See F. S. Regs. for requisites of a camp site and of a defensive position.

As a general rule, endeavor to place yourself in your

commanding officer's position and decide upon everything that he would naturally wish to know in each particular case.

Map Reproduction

Every officer should be familiar with the various methods of map reproduction. Many officers of experience appear to be totally unfamiliar with the capacity and efficiency of the various means of map reproduction. They are apparently impressed with the idea that, when the field work is done, a handsome map in colors should be immediately available.

There are many processes of reproducing maps. The various processes may be divided generally into two classes as to capacity and efficiency, viz.:

1. Lithography.
2. Makeshift methods, such as blue printing, the Ellam Duplicator, the hectograph, etc.

The corps, army, or some central map reproducing plant are provided with the former means of map reproduction. These plants are very efficient, and can turn out maps in colors in large numbers sufficient to equip all forces concerned.

Makeshift processes are employed by the G-2 Section at Division Headquarters for a limited number of maps for special purposes, such as plans for a raid, or to make minor revisions or additions to existing maps as may have been acquired by reconnaissance, aeroplane photographs, etc.

It is not worth while to attempt to describe the various map-reproducing equipment in detail in a text-book. Simply remember that some of the makeshift means are: a blue-printing apparatus, the hectograph, the Ellam Duplicator, or the Neo-Cyclostyle and Dorrel processes, and that the lithographic maps are produced in large quantities by large rotary offset presses, or, in some cases by smaller hand presses, and, when the opportunity presents itself, and you are at a Division Headquarters or a large publishing plant, make it a point to examine into the workings of the various map-reproducing paraphernalia.

Lesson XVIII

Aerial Photography

Reconnaissance from the air is of two kinds, visual and photographic. We are concerned here with only the photographic. The purpose of aerial photography is to secure photographs suitable for maps, and individual photographs of areas about which information can not be secured in any other way.

The accuracy of the data obtained from aerial maps and photographs can not be doubted. The camera records in a fraction of a second more than the eye can see and the mind remember in a much longer time. A comparison of Figure 36 and Figure 37 shows this conclusively.

The cameras used are of two general classes. One class is used for taking photographs through the bottom of the plane and the other for taking photographs over the side. Of the first class, that most commonly used is a semi-automatic camera known as the "L" type. Cameras of this class are fastened in cradles inside the ship so the sensitive plate is parallel to the ground when the plane is flying level. These cameras are used almost entirely for map making. All cameras of the second class are adaptations of the familiar Graflex. They are aimed in much the same manner as a rifle. These cameras are only used at low altitude, their object to show the ground in relief, and the photographs appear to be taken from a high hill.

Except in most unusual cases, the planes used are a slow-moving type which permits a longer exposure to be made. At the beginning of the flight the pilot is informed of the area or object to be photographed and the altitude at which the photographs should be taken. The camera, after it has been inspected, is placed in the plane and the plane takes off. The altitude and desired location having been reached, the pilot signals the observer and the photographs are taken. If the purpose of the flight is map making, the plane flies back and forth across the territory

to be mapped until the entire area has been covered. These photographs are taken at regular intervals so that each exposure overlaps the preceding one. Thus a continuous picture is secured. See Figure 38.

If only a single picture is desired the pilot flies, if possible, in circles around the object to be photographed and the observer takes the picture from the most advantageous position.

Upon the return to the field the exposed plates are taken to the laboratory, and prints or lantern slides made. Under ordinary conditions this is done without haste. During the recent war, however, speed methods were evolved which made the delivery of dry prints within ten minutes of the arrival of the plates at the laboratory. Prints made direct from the plate are known as contact prints. These are not always suitable for mounting in series as maps as they may vary in scale. This is corrected by making enlargements. One print is enlarged to the desired scale and the balance of the prints of the series are scaled to it. This is done by making the distance between two objects which appear on both prints the same. Sometimes it is desirable to have a number of officers study the same territory at once. In this case a lantern slide is made and thrown upon a screen.

The area covered by a particular photograph or series of photographs may be determined by comparison with a drawn map of the territory over which it is known the flight was made. Roads, railroads, public buildings, water ways, and other permanent features serve as the means of identification. Attention is invited to Fig. 36 and Fig. 37. The intersection of the road and the electric line, and the triangle formed by the electric line and the two roads, both serve as a means of locating the position of the photograph on the map.

Figure 38 illustrates what is known as a "mosaic," so called from the fact that it is made by fitting the several pieces together. This is usually done by men who have had training in the work, and who cooperate with the intelligence section in the field. From photographs fur-

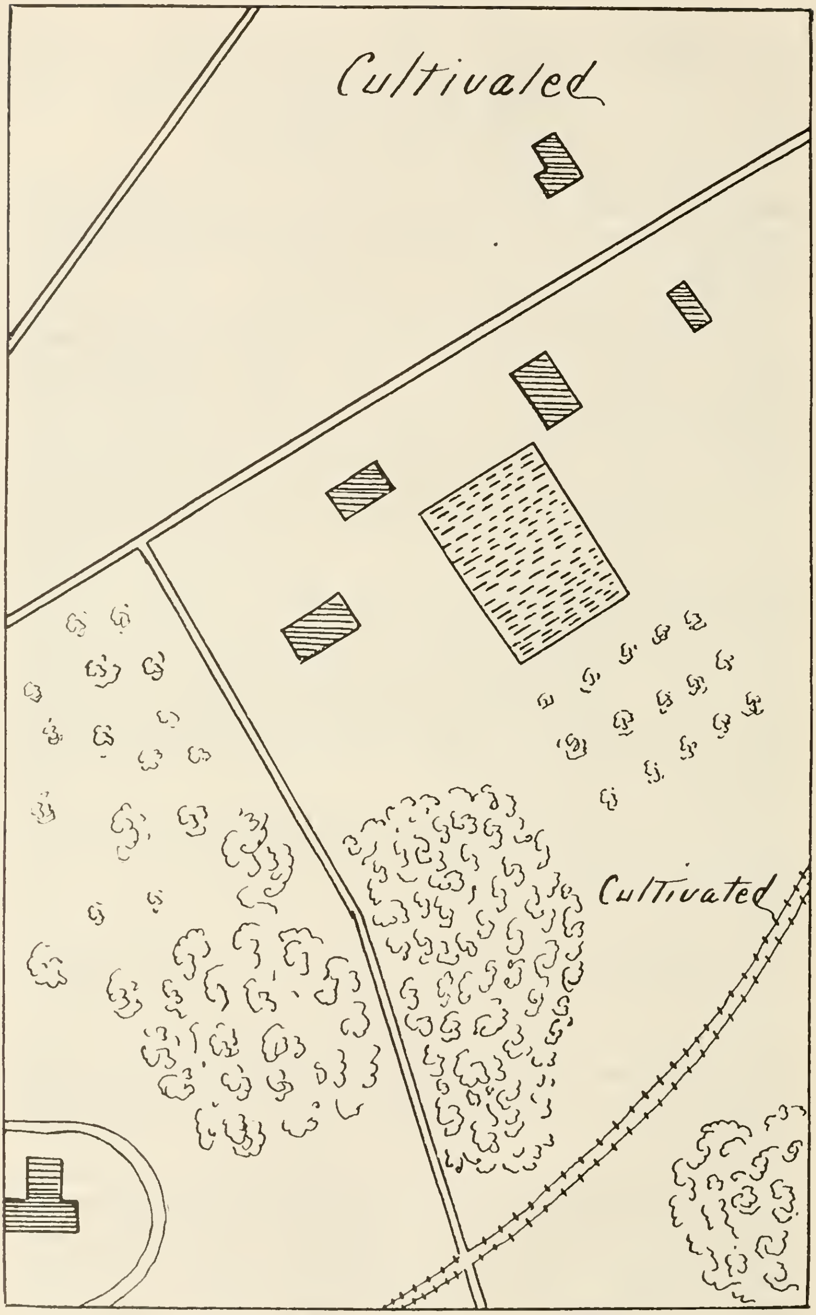


Fig. 36

Fig. 37

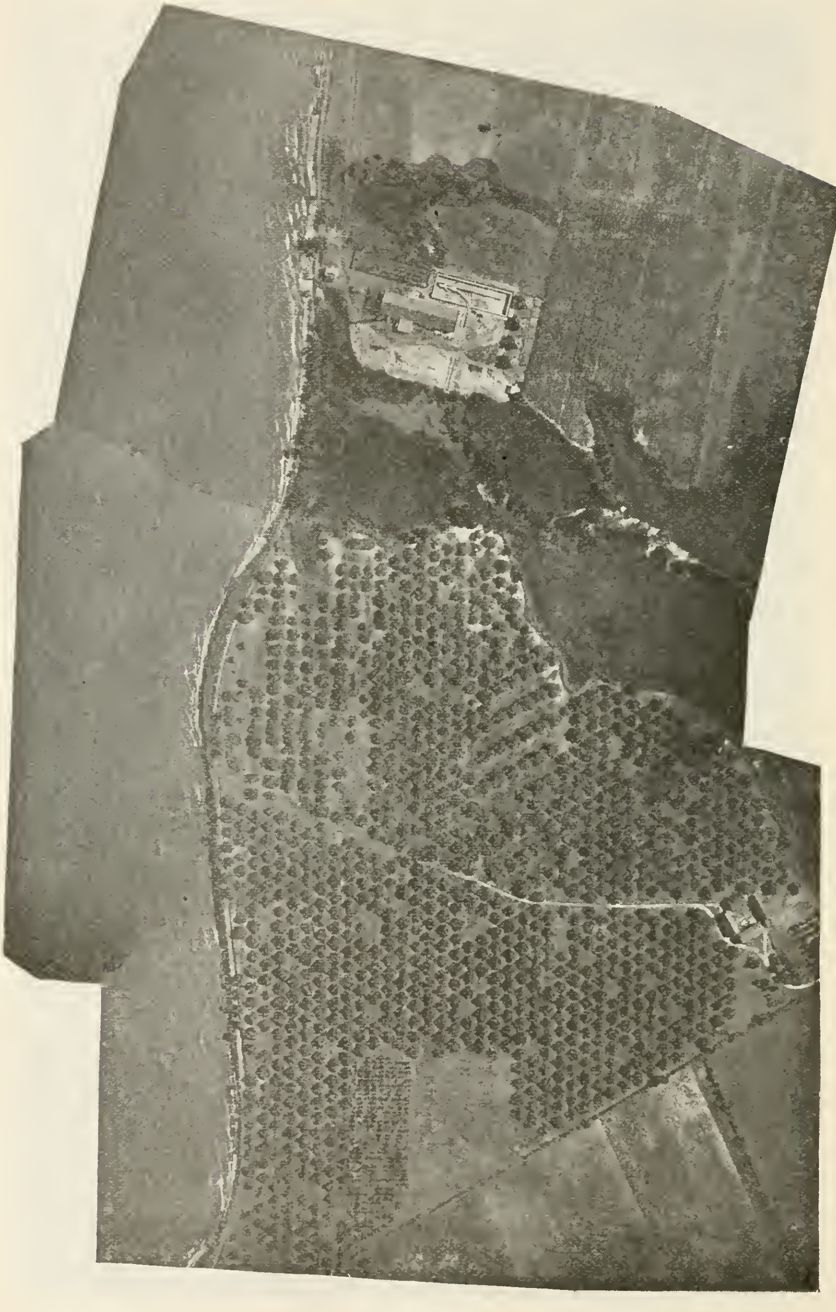


Fig. 38

nished him the commanding officer is able to correct his maps, and study the terrain in front of his troops. By comparison with previous photographs the intelligence section can detect changes which have been made in the enemy defenses, and also check the results of their own attacks.

At headquarters the photographs are filed as soon as they are received. The coordinates of the center of the rectangle covered by each photograph are determined, and it is under this number that the print, lantern slide, and negative are filed. Thus all the photographs of any point are filed together and are instantly available.

PART THREE

Panoramic or Landscape Sketching

Introduction

The following five lessons are intended to convey to the student, in the simplest manner possible, the necessary basic principles of landscape sketching, and the use of range cards for the various arms.

In military landscape sketching, it is indeed obvious that the results to be obtained are purely utilitarian and will in nowise be subject to artistic criticism.

The principal reason why the average person finds it so difficult to draw what is before him, is that he fails to see, to comprehend what his eye surveys. This may sound like a contradiction, but to prove the point, ask the average man to look at a landscape for five minutes, then to turn away and describe what he has seen. His answer will quite likely prove that what was before him made but a slight impression on his mind, he being able to remember but few details with little or no idea as to relative positions.

The following lessons have been planned as to time and sequence so that it is believed the average student should possess a fair working knowledge of the subject in the time allotted. Having pursued the subject thus far the student involuntarily continues.

The importance of landscape sketching has been greatly enhanced by the application of more scientific methods to the control and direction of artillery and small arms.

Lesson XIX

Delineations

Indoor Work

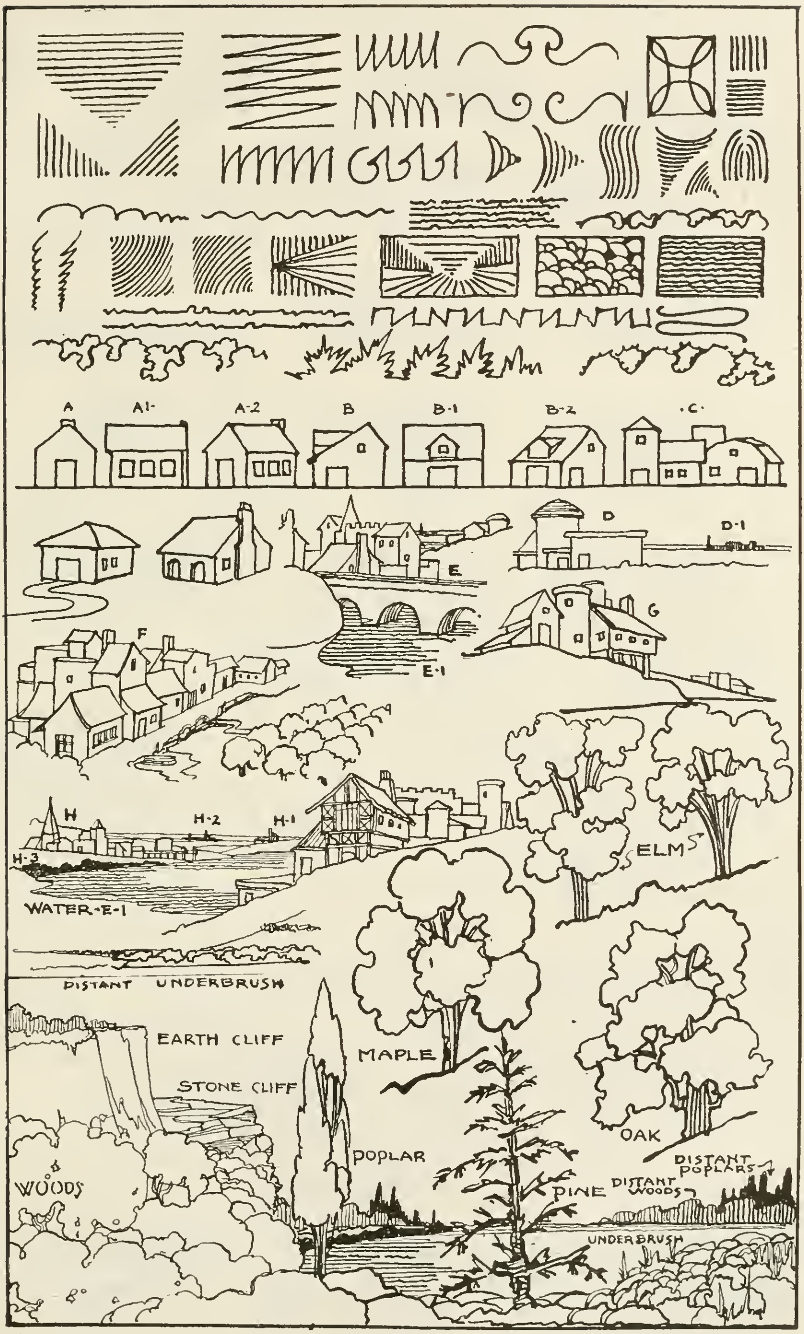
In order that a beginner in landscape sketching may be able to sketch freely and rapidly on the ground, he must first practice delineations or, if you please, conventional signs. The only difference between delineations and conventional signs, is that the former includes an endeavor to represent actual shapes, whereas conventional signs represent only the general subject without any effort to represent the particular subject in the sketch. Delineations, therefore, include a certain type of conventional combinations of lines intended to assist the eye in imagining the actual shape of the subject represented.

Refer to Figs. 39 and 40. Practice various combinations of straight lines without ruler, then combining various curves and lines, finally so combining them to represent actual objects such as fences and houses, ground formations and trees. When individual figures can be made with ease, attempts should be made to combine them into imaginary landscapes. The parallel straight lines have two uses: shading interior of a delineation and as a conventional sign for plowed or cultivated land.

No hard and fast rules apply. The various illustrations given in Figs. 39 and 40 furnish an ample variety in delineation. Take care that the eye gets the outline carefully before any line is drawn. Lines must be made with one sweep and not slowly and laboriously. No erasures should be permitted during these exercises. If sketch does not suit, repeat the exercise. The student will find the work new and interesting, and will be most agreeably surprised with the progress made.

For this lesson the student should be provided with the following:

1. Pencil, Faber's HB.
2. Improvised drawing board.
3. Four thumb tacks.
4. Good grade unglazed white paper.



A
A1
A-2
B
B-1
B-2
C
D
D-1
E
E-1
F
G
H
H-2
H-1
H-3
WATER-E-1
ELMS
DISTANT UNDERBRUSH
EARTH CLIFF
STONE CLIFF
MAPLE
WOODS
POPLAR
OAK
DISTANT POPLARS
PINE
DISTANT WOODS
UNDERBRUSH

Fig. 39

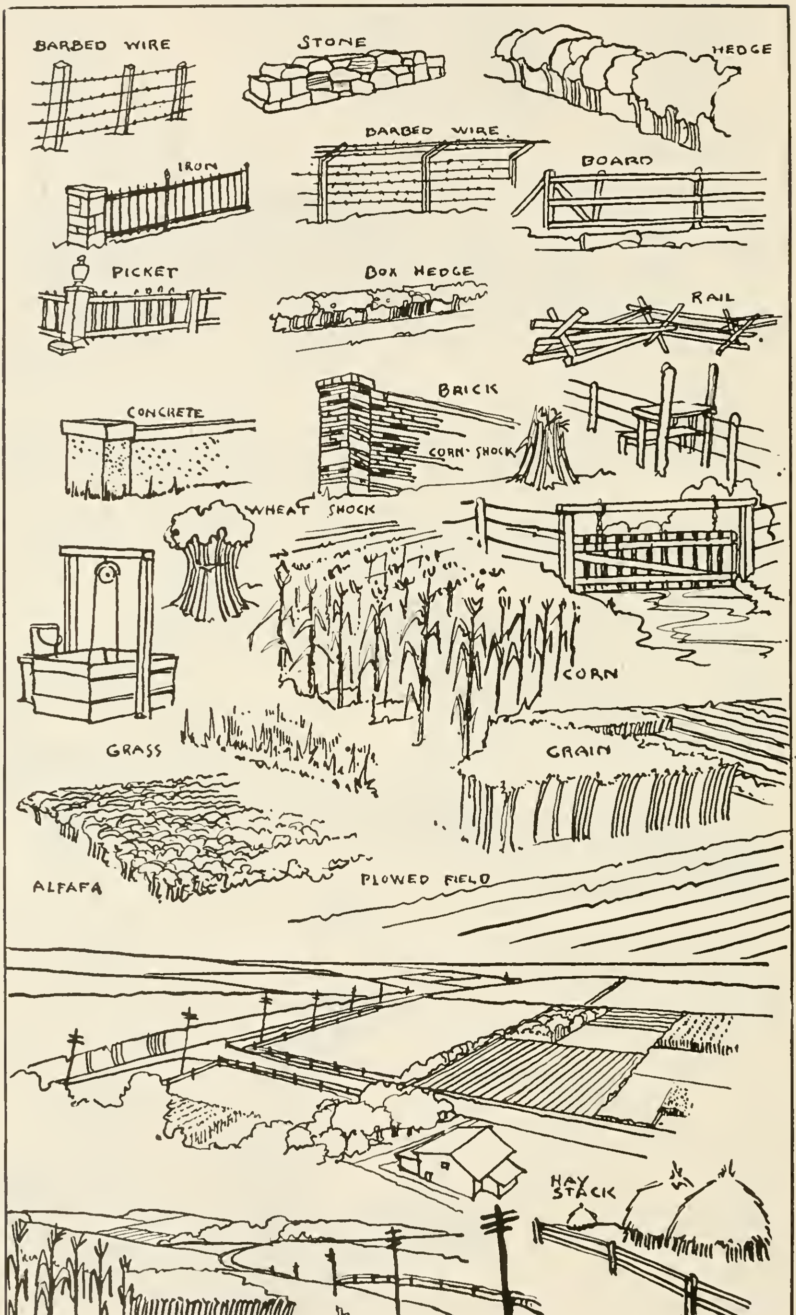

BARBED WIRE
STONE
HEDGE
BARBED WIRE
IRON
BOARD
PICKET
BOX HEDGE
RAIL
CONCRETE
BRICK
CORN SHOCK
WHEAT SHOCK
CORN
GRASS
GRAIN
ALFAFA
PLOWED FIELD
HAY STACK

Fig. 40

Lesson XX

Delineations *(Continued)*

Indoor Work

The student having become adept in the delineations in Lesson I, will now be given a number of model sketches with instructions to copy them to the best of his ability. He should be cautioned not to hurry but to study the given sketch carefully in order to determine the most essential features. Note the form of the skyline. Draw this in lightly after first making light pencil marks where the most marked features appear to lie. Now draw in the lines that show the ground shapes, hills and ravines, being careful to make the lines somewhat heavier as the objects get nearer until the immediate foreground is reached near the bottom of the sketch which may be made by using the side of the pencil point to get proper weight.

An illustration of the development of the copy of a sketch is given in Fig. 41 and Fig. 42. Starting with the skyline, the sketch finally develops into a very good copy in the sixth stage at (*f*). In some cases it may be necessary to erase parts of the lines already made, where nearer objects interrupt or obscure them.

The student should be cautioned that the essential features only, are to be represented in the sketch. In other words, things of no military value should be omitted or simply outlined and shaded in. It is here where a well made sketch is of more importance than a landscape photograph. The camera has no sense of selection but represents the *whole* truth and those in the foreground most accurately and carefully. It will, for example, picture accurately each head of wheat for a hundred yards in front of the camera, while the sunken roadbed will be slurred over almost unnoticed. The sketch would here dismiss the wheat field with four lines, with probably the word "wheat" written in, and give most careful detail to the sunken road and fences at the other end of the field.

Keeping the above instruction in mind, let the student make sketches from such photographs as are given in Figs. 43, 45 and 46. Fig. 44 is an example of sketch covering the same ground as that shown in Fig. 43. Note the prominence of the fence and observation tower in the sketch and compare with the camera's effort.

For this lesson the student should be provided with the following:

1. Pencil, Faber's HB.
2. Improvised drawing board.
3. Four thumb tacks.
4. Good grade unglazed white paper.
5. Lead pencil eraser.

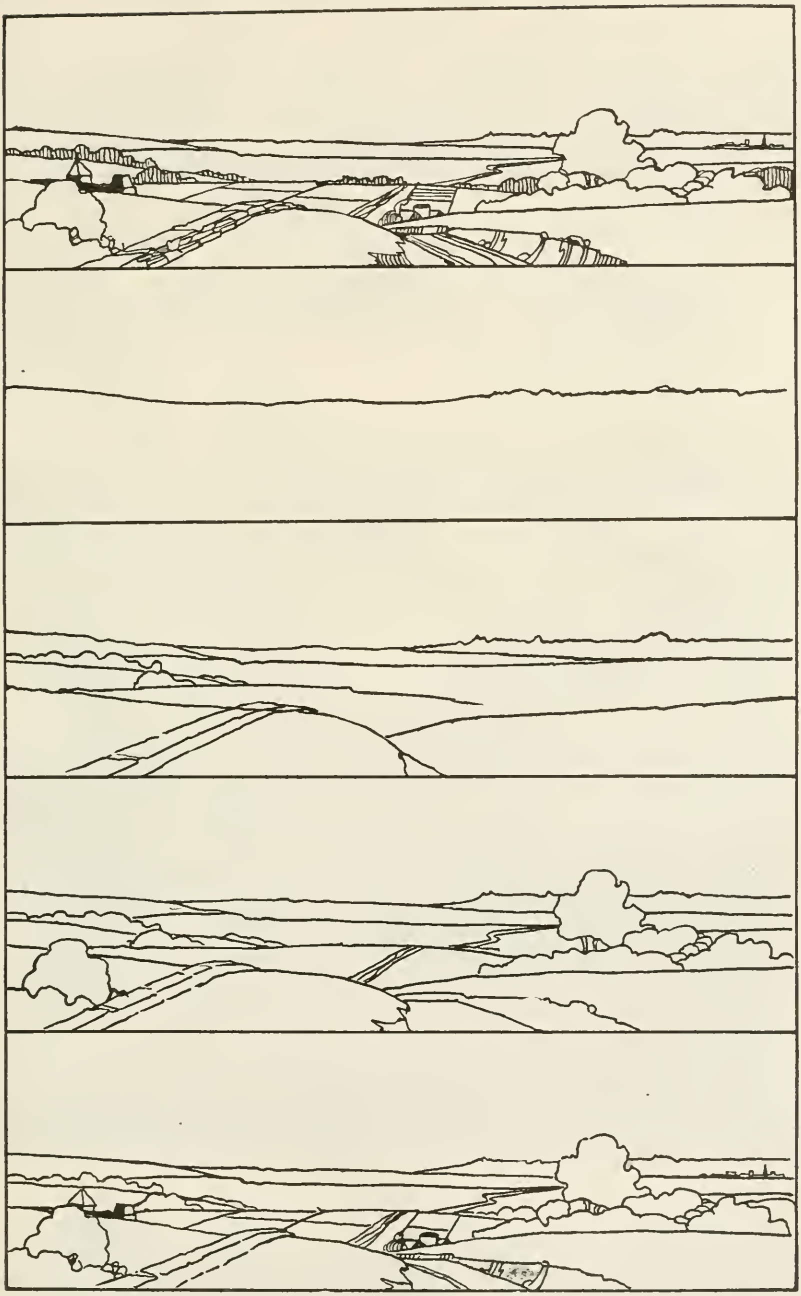


Fig. 41

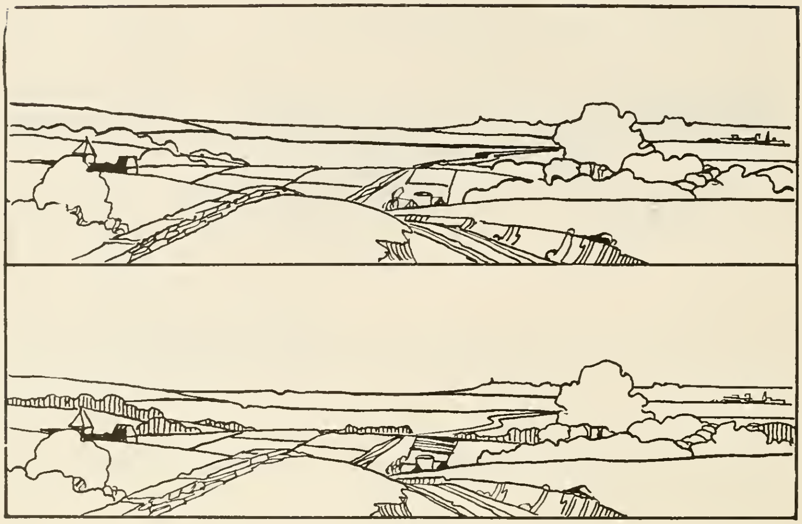


Fig. 42

Fig. 43

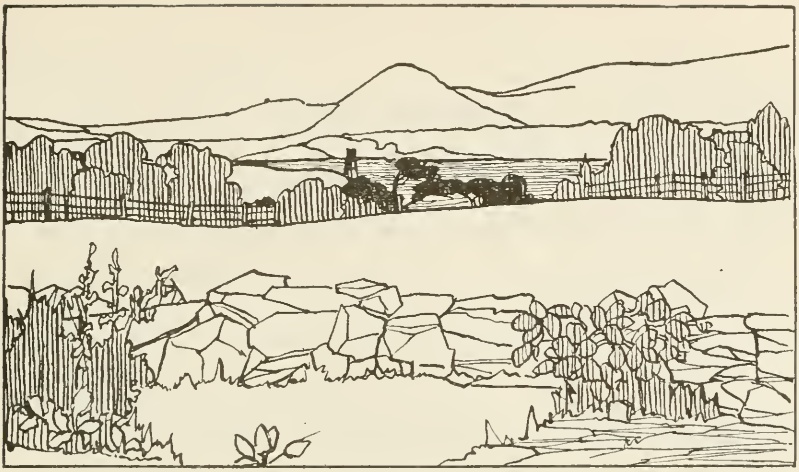


Fig. 44

Fig. 45

Fig. 46

Lesson XXI

Outdoor Exercises

Explanation of Mil Scale and Improvised Aids

Having completed the preliminary exercises in "Delineations" the student is now ready to proceed to outdoor sketching as far as making representations on paper of the objects before him. There is, however, one important phase of military sketching that must not be lost sight of. A military sketch, when completed, should be of such a nature as to be readily understood by any other person. The information portrayed on the sketch includes not only the objects themselves, but their relative positions, not only in distance, but often of more importance is the horizontal or lateral relation. It is also convenient to have all sketches drawn to the same scale, so that these relative distances will be portrayed instantly to the eye without the assistance of a special scale for each individual sketch. As the mil system of measuring angles has already been introduced to our service, the student is presumed to understand its principles. For those who may not have had instruction with mil measurement instruments, the following explanation may be of value.

One mil is that angle whose tangent is 1/1000, or in other words, it is the angle formed at the eye by two lines that exactly subtend one yard at 1,000 yards away from the eye, or, by similar triangles, it subtends one-half yard at 500 yards. It will thus be seen that the linear distance of the tangent varies in proportion to the length of the radius, although the angle remains the same. If we were to interpose a ruler exactly one yard in front of the eye in the above case, the tangent would be 1/1000 of a yard in length, or .036 inch.

The Musketry Rule is an instrument issued by the Ordnance Department, designed to measure mils when held at a fixed distance from the eye. The smallest divisions indicated measure angles of 5 mils. The actual length of this division is dependent on the length of the string, which

determines the distance at which it is to be held from the eye. If, therefore, we fix the distance the ruler is held from the eye to 15 inches, the angle will vary in proportion to the number of divisions we would subtend on the rule by the legs. This is the principle that is made use of in landscape sketching for locating prominent features of the ground on the landscape sketch.

There has been developed, at the Infantry School of Arms, what is known as the "Sketching Pad." It is a pad of specially ruled paper for the convenience of the sketcher. (See Fig. 47, which represents one of the sheets on a reduced scale.) In practical use, the sheet should be $8\frac{1}{2}$ by $5\frac{1}{2}$ inches. Vertical lines should be very light, preferably blue, or even uninked, simply leaving a light crease. These vertical lines are of value as guides in dropping features of the landscape, located over the top of the paper, down to the sketch strip. The intercept between these vertical lines equals the 50 mils division of the Musketry Rule. The pad should, therefore, be provided with a string so arranged through an eyelet near the center of the top, as to insure that the paper is held exactly 15 inches from the eye each time the pad is held up for orientation. With this length of string, the interval between the vertical lines subtends 50 mils. The four horizontal lines drawn just below the center of the sheet should be of the same weight as the vertical lines just described. These horizontal lines are of value as guides in placing features of the landscape located by means of the vertical edge of the pad. The highest point of the sky-line must be located somewhere on the top line of these four horizontal lines.

At the top of the paper are two heavy orientation marks and three horizontal black lines defining divisions marked for the Target, Range and Deflection. At the bottom, on the left, is a place for a description of the position from which the sketch was made. In the center is a circle to contain the number of the sketch. By the side of the circle will be drawn an arrow with one barb, to show the magnetic north. On the right are spaces for the time, date, name, rank and organization of the sketcher.

The use of the sketching pad may perhaps be illustrated to the beginner by its analogy to a window, through which an observer is looking at a landscape. If the observer is standing back from the window at a certain distance, each window pane will contain a certain section of the landscape, and the width of each pane will also correspond to a certain number of mils. Therefore, if the size and shape of the window panes were altered to correspond to the section described on the sketching pad by the vertical and horizontal lines, it would serve as a transparent sketching pad. Now, if, instead of the transparent window panes, we were to place a paper on which we could outline the landscape as seen through each pane, the result would be a landscape sketch covering the area seen through the window. The idea above expressed may be more readily understood by referring to Fig. 48.

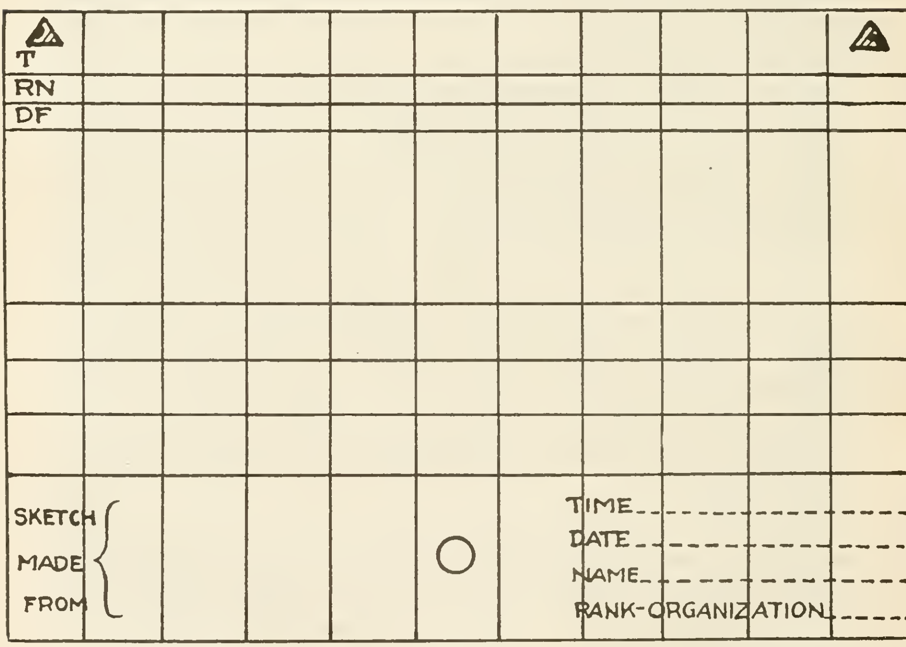


Fig. 47

Various methods analogous to the window have been improvised to assist beginners in landscape sketching, as, for instance, the wire screen illustrated in Fig. 49. This screen

could be improvised by almost any one, and by fixing the eye notch at a fixed distance perpendicular to the screen, the intercepts between any two wires may readily be made

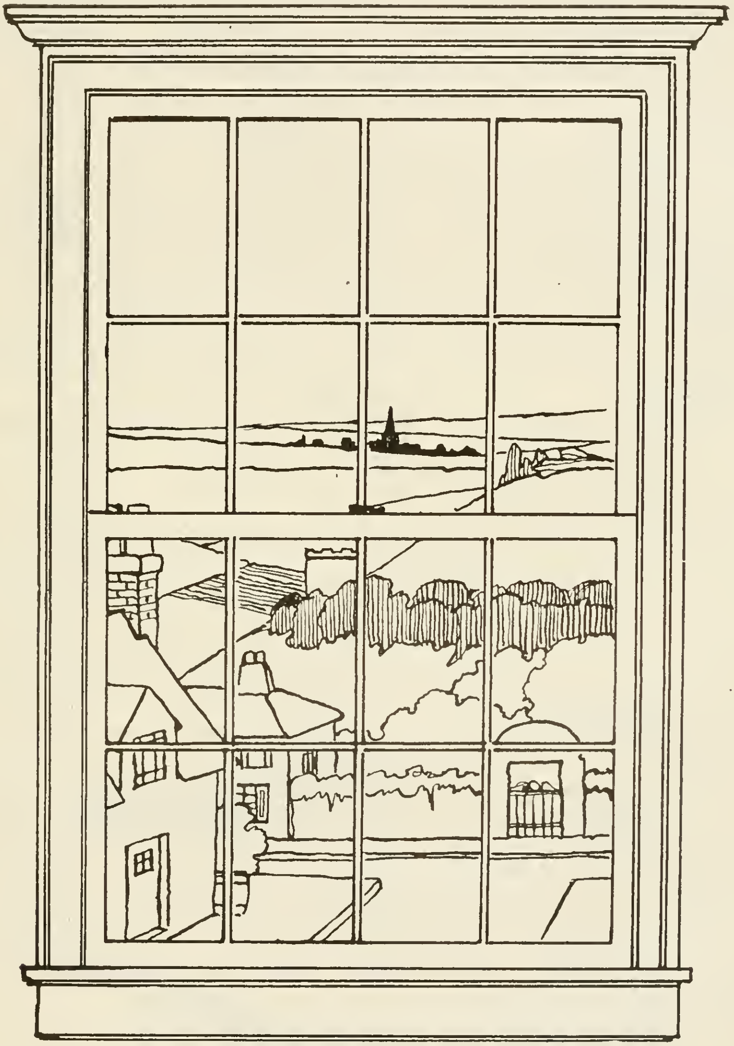


Fig. 48

to correspond to a certain fixed number of mils. The appearance to the observer will be something like that illustrated in Fig. 50, and by having cross-section paper with

the lines corresponding to the screen wires, the view may very readily be transposed to paper by the sketcher. When this wire screen is used, it should, of course, be set up on a stake and remain stationary until the sketcher has completed his sketch for the area covered.

In the absence of standard sketching pad blanks, the sketch may still be made to the same scale by other improvisations. Any ruler marked with uniform divisions held at a determined distance in front of the eye so that the prominent divisions will intercept a given number of mils—for example, let us assume that the ruler is marked in $\frac{1}{4}$ inches, and we desire that one of the divisions shall equal 25 mils. If we remember that one mil equals one yard at 1,000 yards, at what distance will $\frac{1}{4}$ inch equal 25 mils? This can be determined by simply substituting values in the formula $\frac{W \times 1000}{M}$ which formula expresses the whole principle of the mil system. In this case $W = \frac{1}{4}$ inch, $M = 25$ mils. Solving the formula with these values, $R = 70$ inches, therefore, if we make a cord 10 inches long, and always hold the ruler at cord's length from the eye, it will in fact be a true mil rule. Of course, if no cord is used, the rule may be held approximately at the required distance from the eye, but it will then be only approximately correct in mil measurement. This use is illustrated in Fig. 51. Another simple expedient that has long been in use by sketchers and painters is that of using a lead pencil, held at a uniform distance from the eye, to measure lateral distances between objects in the landscape that is being sketched. When the pencil is so used, it is usual to use the thumb as a sliding indicator. Examples of this use of a lead pencil are given in Figs. 52 and 53.

For this lesson, the student should be provided with the following:

1. Sketch pad, with a stiff back and cord.
2. Pencil, Faber's HB.
3. Lead pencil eraser.
4. Any improvised instruments, such as screen mentioned above, and ruler for use as mil scale.
5. Compass.

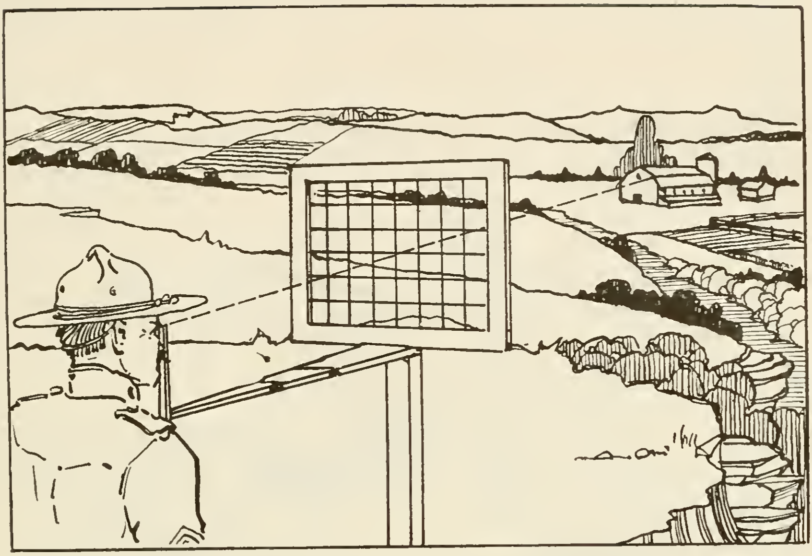


Fig. 49

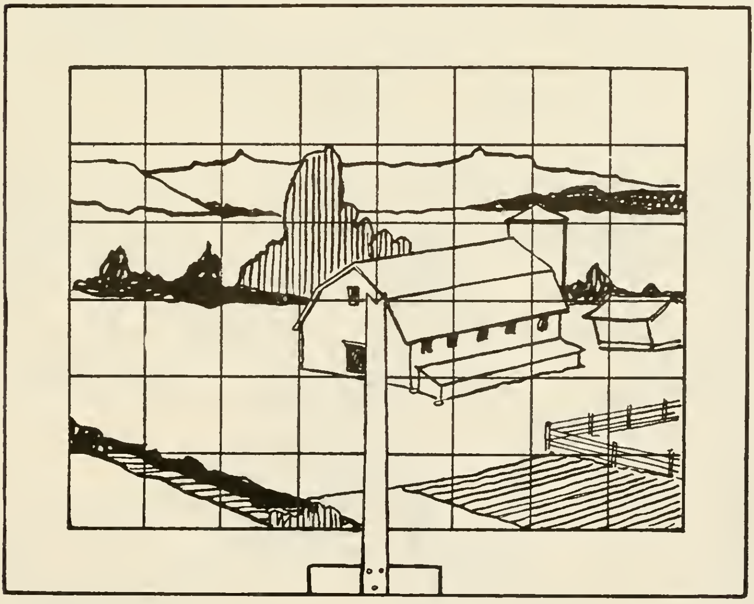


Fig. 50

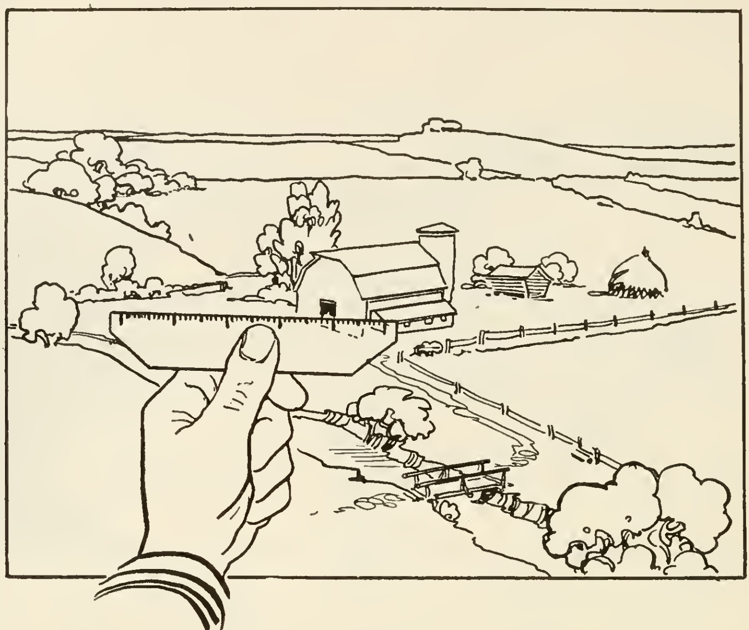


Fig. 51

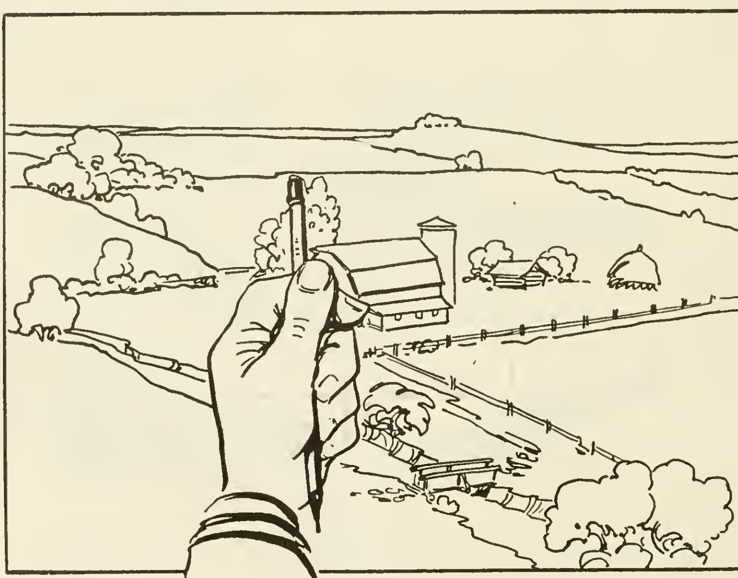


Fig. 52

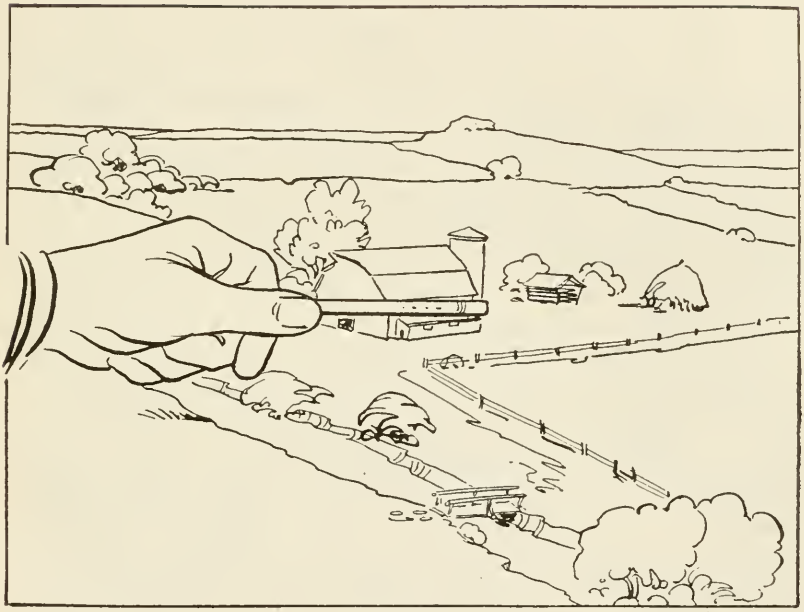


Fig. 53

Lesson XXII

The Sub-Sketch

Up to the present, the student has been concerned only with the making of the sketch proper. It may often happen that the scale of the sketch does not permit certain objects to be shown in sufficient detail. To draw the whole sketch to larger scale would entail unnecessary time and labor. It is, therefore, found convenient to draw a sub-sketch of very important features. The method shown in Fig. 54 is self-explanatory. The field glasses should be used for such sketching.

In conjunction with road sketching, it is frequently of utmost military importance to show the appearance of the landscape from given points on the road, even though such features will actually be beyond the limit of the road sketch itself. This method is illustrated in Fig. 55. Usually, these sub-sketches are made to a standard scale, though sometimes it is permissible to exaggerate the vertical dimensions slightly. The sub-sketches made in conjunction with the road sketch are usually made by an assistant, numbers being placed at points on the road to correspond with the numbers placed on the sub-sketch. However, if there is no assistant for this purpose, the sketches may be placed on the road sketch paper itself, as illustrated in Fig. 55, lines being drawn to represent the approximate angle subtended by the view. Usually these views are made to include important features on the road itself, such as bridges, and cuts or fills.

The student should equip himself the same as in Lesson III.

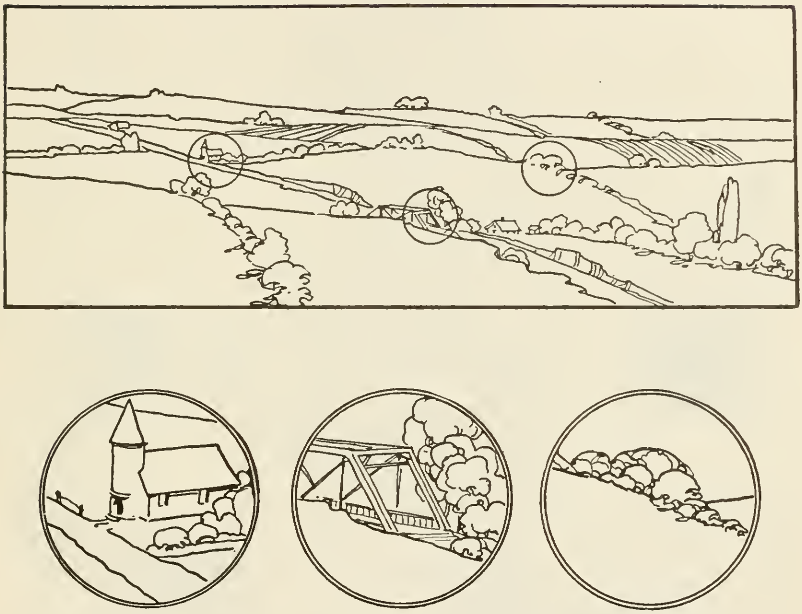
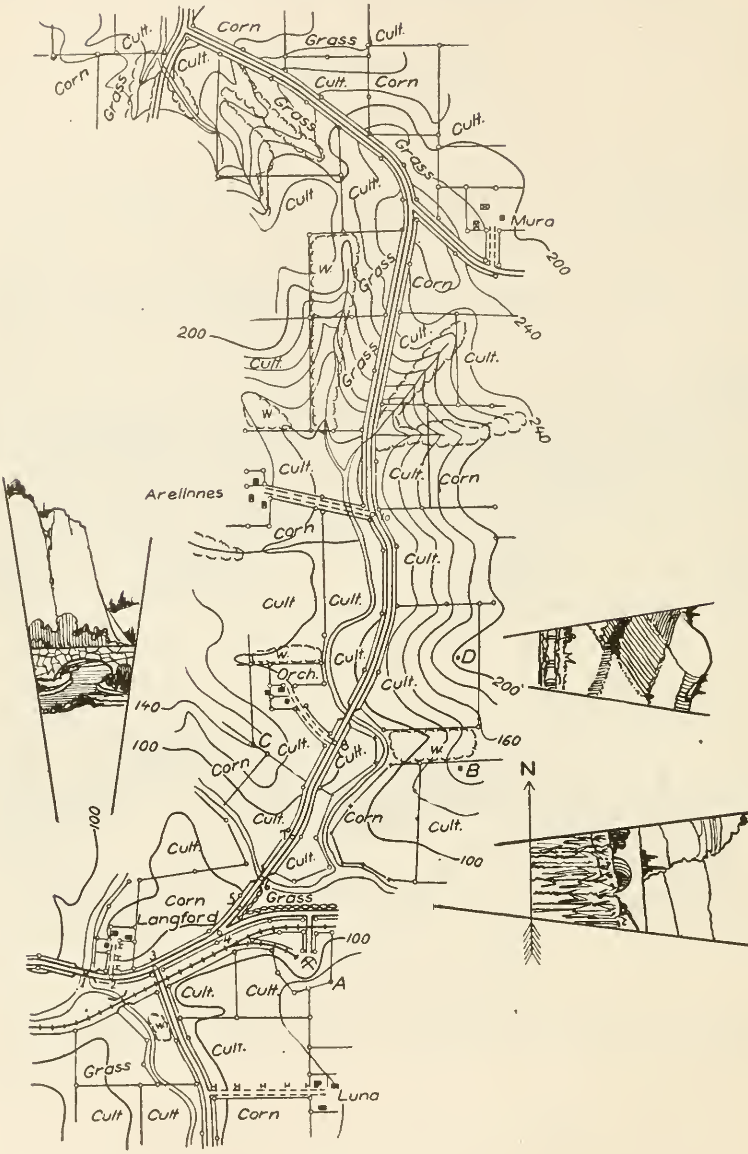


Fig. 54



ROAD SKETCH

Scale, $\frac{1}{20000}$

V. I. 20′

Fig. 55

Lesson XXIII

Range Data

The student should now be required to complete sketches on the standard sketch pad in the manner shown in Fig. 56, that is, all important military features should be shown, not only on the sketch itself, but a line should be drawn vertically from the sketch itself till it intersects the three horizontal lines near the top, and on this line should be written in the proper place, the target, the range to that target and the deflection to that target from a given reference point. In all cases, the reference point will be similarly indicated with a zero deflection. Care should always be taken that the name of the place from which the sketch was made is not omitted from the lower left-hand corner and that the single barbed arrow, giving the magnetic north, appears near the circle at the center. The number near the circle should always indicate the relative position of sketches from enemy right to enemy left. The range should, when practicable, be measured with a standard range finder.

Frequently, when the principal thing needed is the military information of the sketch, the sketch itself may be omitted for the purpose of saving time, and direction lines only are then drawn from the small circle towards the targets. At an approximate distance (sometimes, but not always measured to scale) is drawn a quick sketch representing the target only, or sometimes only an X is placed on the line and a word written, such as "ford," "tree," etc., near this mark. An example of this case is given in Fig. 57, which represents what is called the range card, for the same ground given in Fig. 56. It is thus seen that a range card is a simplified landscape sketch which does not require any pictorial ability on the part of the sketcher. The necessary fire data are placed on the upper left-hand corner of the range card in the place provided on the blank. The deflection, however, is given near the top, and

is measured in mils from the reference point. The range is also frequently written along the direction line toward any target. The targets are also numbered from enemy right to enemy left, and the firing data for each target are recorded in the space provided. The illustration given in Fig. 57 is that of a machine-gun range card. These cards are made out for each individual gun, and the number in the circle may be supplemented by such additional data as the particular case may require, for example, "No. 1 Gun, Company A, 335 M. G. Bat." The machine-gun range card remains at the position of the gun when the machine-gun crew is relieved. The sketch given in Fig. 58 is another illustration showing how firing data are expressed on a landscape sketch. Though it is desirable that all sketches should be uniform in appearance, the only essential feature that must be adhered to is that the firing data must be expressed directly above the target and near the top of the sketch.

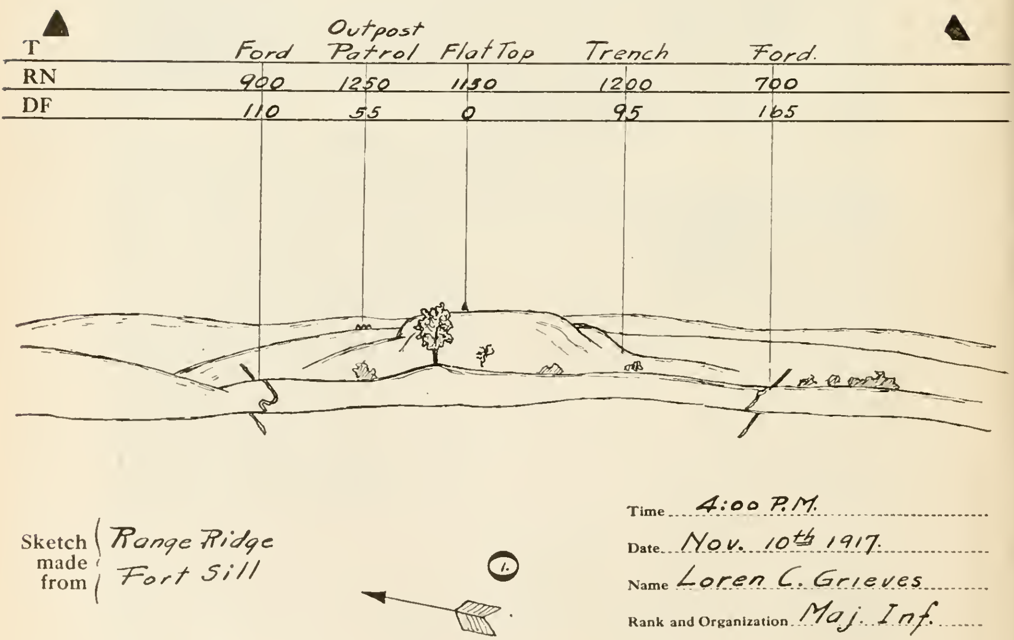
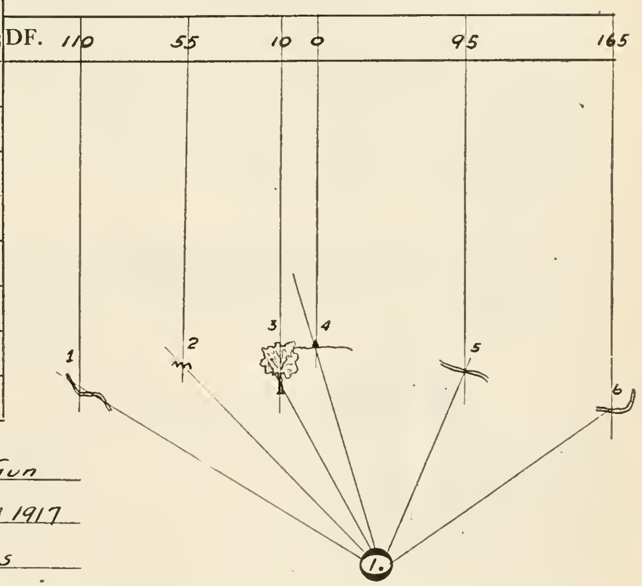


Fig. 56

Fig. 59 illustrates a landscape sketch as applied to giving firing data for field artillery. For artillery sketching purposes, the sketch pad blanks should be altered by adding additional horizontal black lines near the top for placing the artillery firing data. There should be at least a one-inch space above the upper horizontal line, used for writing in names of registration points, targets, etc., and for entering their estimated and measured ranges; measured ranges should be underscored. The space covered by the six horizontal lines are used in the order given for entering deflection, deflection difference, site, corrector, and range for the gun position. The deflection difference and corrector of any particular target should be entered only after this data have been determined by actual fire. The deflection (actual deflection from the aiming point)

MACHINE GUN RANGE CARD

TARGET	R N	A S° (DEGREES)	AS^M (MILS)	C B (COMPASS BEARING)
(1) Ford Bullet Creek	900	-15'	-5	20
(2) Patrol	1250	+15'	+5	40
(3) Lone Tree	750	-15'	-5	56
(4) Flat Top Mark	1150	+29'	+10	64
(5) Trench	1200	0	0	95
(6) Ford	700	-18'	-6	120



Position Range Ridge # 1 Gun

Hour & Date 4:00 P.M. Nov. 10th 1917

Name Loren C. Grieves

Rank & Organ. Major Infantry

Fig. 57

should already be computed and entered before opening fire, but that data should be changed after delivering fire so as to show the actual data determined by fire. The space below the six horizontal lines and above the body of the sketch is used for noting the angular distances from the reference point to prominent points on targets shown. These angles should be recorded immediately below the lower of the six horizontal lines. Other data pertaining to targets, notes, reference to sub-sketches, etc., may also be placed in this space. The sketch proper is usually confined below the top dim horizontal line, in the same manner as in the sketch previously discussed. The space below the sketch proper should have the same notation as the previous sketches discussed, adding condition of the weather, which is needed in calculating artillery data, and of course such other miscellaneous notations as may be necessary in any particular case.

The student should equip himself the same as in Lesson III.

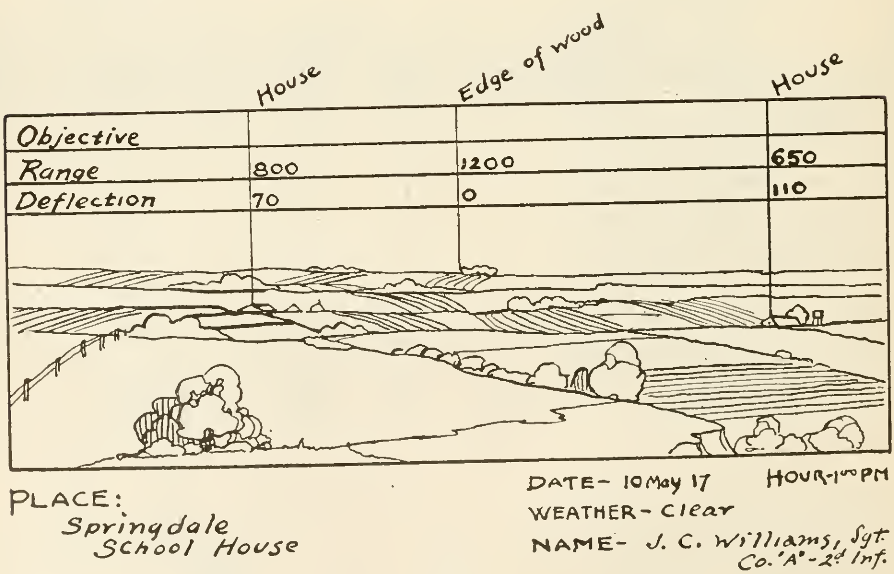


Fig. 58

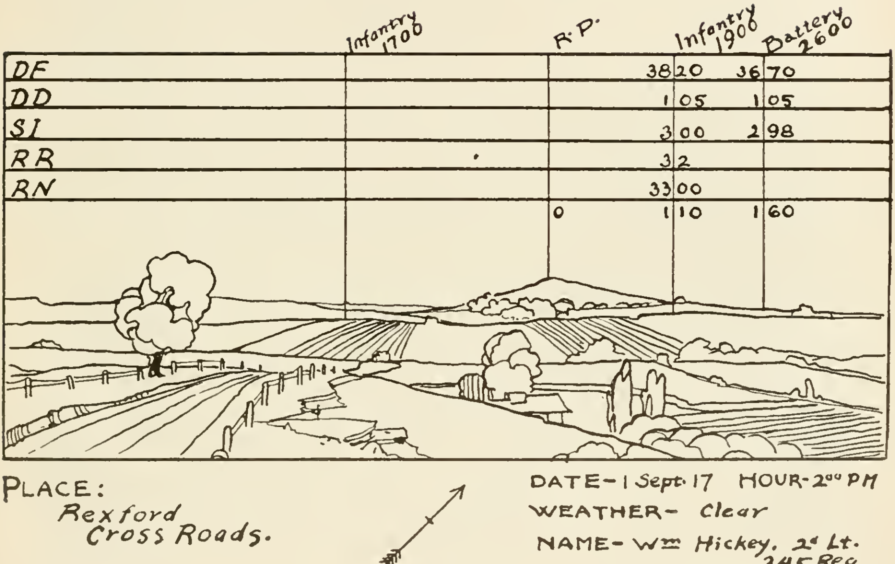

Infantry 1700
R.P.
Infantry 1900
Battery 2600
DF
DD
SI
RR
RN
3820
3670
105
105
300
298
32
3300
0
110
160
PLACE:
Rexford Cross Roads.
DATE- 1 Sept. 17 HOUR- 2oo PM
WEATHER- Clear
NAME- Wm Hickey. 2d Lt.
345 Reg.

Fig. 59

PART FOUR

Suggestions for Instruction at Training Camps

The author has had considerable experience in instruction pertaining to both map reading and sketching at training camps, and the following suggestions may prove of some value to those upon whom this duty may fall in the future.

With the intensive course of training pursued at training camps, the time usually allotted to sketching and map reading is very limited, but our noncommissioned officers. and enlisted men in the Intelligence Platoons of Headquarters' Companies should have considerable training in this subject as it constitutes a major portion of their work in actual campaign. Let us assume that time is available for five lessons of two hours each for map reading, and that the same amount of time is available for sketching. With this limited time available, it is a foregone conclusion that the instructor must work against time throughout the course. Another handicap is the limited number of instructors proportionate to those undergoing instruction, but, regardless of these disadvantages, much may be accomplished if the right methods are pursued.

Map Reading

The instructor should provide the following equipment before the instruction begins:

1. A gridded map of the local terrain. If the local map is not gridded, secure, in addition to the local map, a gridded map for each student. The Emmitsburg Sheet, unmounted, of the Gettysburg-Antietam Area, 3″ = 1 mile, is an excellent sheet for instruction purposes. They can be purchased from the Book Department, General Service Schools, Fort Leavenworth, Kansas, at slight cost.

2. Pencils: 1 HB lead pencil, and one pencil each of the following colors: red, blue and green.

3. A compass.
4. A protractor.
5. A triangular ruler. (This will also be needed later in sketching.)
6. A scratch pad.

First Lesson (Out of doors): Equipment—Map of local terrain, compass, ruler, scratch pad and lead pencil.

Subject: Orientation, distance and direction.

Assemble the class at some good point of observation. Issue equipment for the day. Find out if there are any of the students who have some knowledge of map reading. If so, assign them as chiefs of squads. Explain the compass—true and magnetic meridians. Explain how to orient the map under various conditions. The various methods of locating your own position on the map.

Explain all about scales. With the map oriented, select various objects on the ground that are located on the map. Have the students first estimate the distance to the object, and then have them scale off the distance on the map. Have them scale the distance between villages, etc., by way of connecting roads.

Explain what is meant by the true and the magnetic azimuth. Give them several exercises in determining the azimuth of points, both from the map by the use of the protractor, and from the ground by use of the compass. Give them a series of distances and azimuths and require them to plot a course of about 1000 yards. If time is available have them trace this course on the ground, substituting pace for yards.

Second Lesson (Indoors): Conventional Signs. Equipment—Map, scratch pad and lead pencil.

First designate about thirty of the most important conventional signs and require the students to draw them, emphasizing the importance of neatness and size. Let the student write the name and draw each different conventional sign found on the map. Without map or book, read off a list of, say, 25 conventional signs, and have the

students draw them, allowing thirty seconds for each sign. Then have the students exchange papers for correction, using book for reference if necessary.

Third Lesson (Indoors): Contours. Equipment—Contoured map and colored pencils.

Explain what contour lines are by means of a rutabaga, an imaginary island, or any other means. (See text.) If possible have some moulder's wax available, and illustrate the various peculiarities of contours by moulding figures of various slopes. Have the students locate the highest point on their maps, the lowest point. Assuming that the highest point is 720 feet and the lowest point is 380 feet, have them color in green all area below 500 feet, in red all area between 500 and 600 feet, and in blue all area above 600 feet.

Fourth Lesson (Indoors): Coordinates. Equipment—Gridded map and a lead pencil.

Explain coordinates, the necessity for precise locations in military operations. The instructor and class together should then locate several points and lines by means of coordinates. The class should then be issued several problems involving locations by coordinates and a time allotted for the solution of same. The instructor should then name the coordinates of, say, twenty points requiring students to place figures at the points, as 1, 2, 3, etc. The instructor will then call upon individuals to name the locations of the various points, as, for example, No. 1, the Taylor School House; No. 2, Hill 568, etc.

Fifth Lesson (Indoors): Scales. Equipment—Lead pencil, pad, ruler and protector.

Explain the Normal System of scales. Construction of reading scale of yards. Construction and use of scale of Map Distances. Discuss practicability of slopes. With scale of M.D.'s determine degree of slopes on the map. Improvise and solve additional reading scale problems.

SKETCHING

Necessary equipment to be provided for each student before instruction begins:

1. Drawing board with attachment for reading angles of slope.
2. Compass.
3. Triangular ruler.
4. Pencil, Faber's HB.
5. Eraser.
6. 4 thumb tacks.
7. Drawing paper.

DRAWING BOARD

With large classes it is obvious that it would not be practicable to provide Engineer drawing boards. The tripod, although a convenience for the beginner, is not essential. The following plan proved successful at the Plattsburg Training Camps of 1915: purchase a sufficient amount of soft pine material 12″ by 1″ and saw into boards about a foot square.

COMPASS

Write to the Keuffel & Esser Company, or any other reliable dealer, for samples, and select some good round compass that may be set into the drawing board by means of boring a hole of the same diameter as the compass, and of a sufficient depth to make the top of the compass flush with the surface of the board. By purchasing the compasses in lot, a considerable reduction may be obtained.

ATTACHMENT FOR READING SLOPES

With the many duties incident to training camp life, the men will not have the time nor the paraphernalia for constructing the slope board attachment. These should be placed on the boards before the camp begins. (See Fig. 28.) The process is simple, and with the aid of a few trained enlisted men, the work can soon be accomplished.

TRIANGULAR RULER

Go to some planing mill and secure a sufficient number of triangular rulers similar to one shown in Fig. 19. Only the plain triangular pieces 6 inches long need be obtained.

PENCILS, ERASERS, THUMB TACKS AND PAPER

These articles should all be secured in advance. The Faber HB pencil is recommended, or any other pencil of about the same degree of hardness. As to the paper, transparent sheets may be obtained at a reasonable rate. This class of paper is of advantage as the rain will not affect it to any great extent, and prints may be made directly from the field sketches; however, for instruction purposes, the ordinary sheets of drawing paper will answer the purpose.

Do not fail to have the equipment as outlined ready for issue at the first period of instruction. The cost of the entire equipment as given above will not amount to much. The compass will be the largest item, but, as a matter of fact, it is a very essential part of a soldier's equipment. Possibly, funds allotted for training camp purposes may be available, especially for the drawing boards and the labor in connection with the attachment for reading angles of slope.

Do not attempt to have several work at the same drawing board. The plan has not proven successful. One or two will do the work and the remaining men will accomplish little. Each must do the work individually.

Lesson I

CONSTRUCTION OF WORKING SCALE—MAKING A FLAT SKETCH

Each student should determine the length of his pace as described in Lesson IX. The scale need not be constructed, but may be transferred to the student's triangular ruler from the compiled scales of paces given at the close of Lesson IX. This completed, have each student traverse a closed course of about one mile. (See Lesson X.) If the class is large, the instructor should pick out several suitable courses and divide the class into sections in order to avoid congestion on the roads.

Lesson II

SLOPES, CRITICAL POINTS, A WORKING SCALE OF M.D.'S

Explain what is meant by critical points, and the drainage system of an area. Explain how to read angles of slope with a slope board. Have all students actually read some angle of slope. Have all students transfer the auxiliary scale of slopes underneath their scale of paces on the triangular ruler as described in Lesson XI. Explain the use of the auxiliary scale of slopes in sketching, and let each student actually apply the principle by measuring a certain distance and determining the angle of slope. Solve several exercises in contouring as explained in Lesson XII. (These contouring exercises should be secured from the General Service School before instruction begins.)

Lesson III

Sketching the relief of a small area. Same as Lesson XIII in the text.

Lesson IV

Position Sketch—Same as Lesson XV in text.

Lesson V

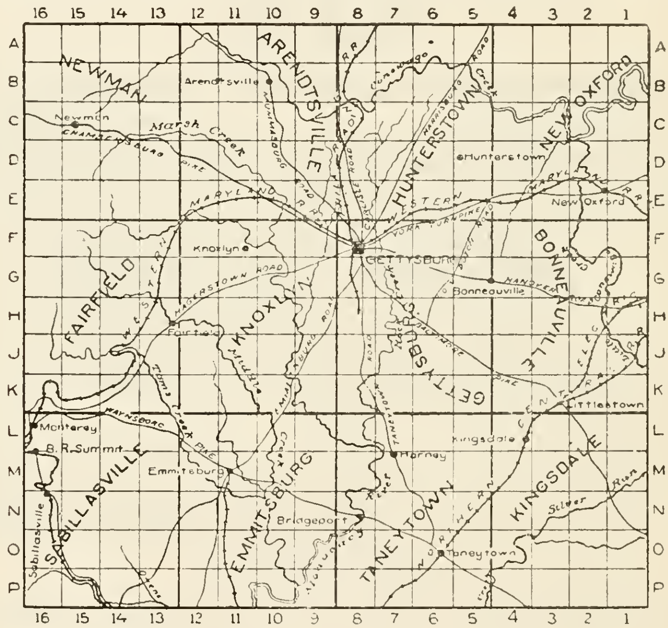
Road Sketch—Same as Lesson XIV in text.

Map Price List

The Gettysburg-Antietam War Game Maps (scale 12 inches to 1 mile), are furnished in 12 quadrangles, each quadrangle consisting of 20 sheets. Each sheet is 18 inches square and covers one and one-half square miles of terrain. A title sheet is furnished with each quadrangle. The quadrangles for this map are designated as follows:

Arendtsville,	Gettysburg,	Knoxlyn,	Taneytown,
Bonneauville,	Hunterstown,	New Oxford,	Fairfield,
Emmitsburg,	Kingsdale,	Newman,	Sabillasville.

Price of each quadrangle is \$3.50, mounted on one piece of muslin, or 65 cents unmounted. The location of the quadrangles of the three-inch and twelve-inch maps is shown on the plate below, which also shows the location of the single sheets of the twelve-inch map. Each sheet of the map may be readily selected by the letters and numbers as shown on the margin. For example, if the single sheet of the 12-inch map showing the city of Gettysburg was desired, it would only be necessary to ask for Sheet 8-F. If the Bonneauville 12-inch quadrangle were desired, the order should read, "One Bonneauville quadrangle, 12-inch map, mounted"—or unmounted, as desired. An order for the Gettysburg-Antietam 12-inch map, means that the entire Gettysburg-Antietam 12-inch map consisting of 12 quadrangles, is desired. The same holds true concerning 3-inch map orders.



[GETTYSBURG—ANTIETAM 3-INCH MAPS

The above twelve quadrangles as shown of the Gettysburg-Antietam War Game Maps may be had in the 3-inch map mounted on one sheet of muslin, price \$3.00, or in single quadrangles, unmounted, price 10c. each.